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PLANT PATHOLOGY

A RECORD OF CURRENT WORK ON PLANT DISEASES AND PESTS

New Mexico College of Agriculture and Mechanic Arts

Published Quarterly for the
Ministry of Agriculture and Fisheries
Plant Pathology Laboratory
Harpenden, Herts

VOLUME 4, No. 1

March 1955

LONDON: HER MAJESTY'S STATIONERY OFFICE

York House, Kingsway, London, W.C.2; 423 Oxford Street, London, W.1
13A Castle Street, Edinburgh, 2; 39 King Street, Manchester, 2;
2 Edmund Street, Birmingham, 3; Tower Lane, Bristol, 1;
109 St. Mary Street, Cardiff; 80 Chichester Street,
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CONTENTS

	Page
Survey of Common Scab of Potatoes in Great Britain, 1952 and 1953. *E. C. Large and June K. Honey*	1
The Mushroom Phorid Fly Epidemic of 1953. *B. D. Moreton and Margaret E. John*	9
Comparison of Aldrin and BHC for the Control of Carrot Fly. *M. W. Shaw and I. McDonald*	11
Aphid Transmission of Cauliflower Mosaic on Turnips. *Brenda M. G. Hamlyn*	13
An Abnormal Form of Skin Spot on Potatoes. *June V. Ives*	17
Effect of Powdery Mildew on the Yield of Spring-sown Barley. *F. T. Last*	22
Effect of Previous Cropping on Eyespot in Four Varieties of Winter Wheat. *C. C. V. Batts and W. E. H. Fiddian*	25
A Rolling Method for Opening Cysts of Potato Root Eelworm. *Elizabeth Reid*	28
The Weather of England and Wales : Spring and Summer, 1954	31
New or Uncommon Plant Diseases and Pests in England and Wales ..	32
Dipterous Pests of Cereals in 1954	34

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PRINTED IN GREAT BRITAIN

SURVEY OF COMMON SCAB OF POTATOES IN GREAT BRITAIN, 1952 AND 1953

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Although Common Scab, *Streptomyces scabies* (Thaxt.) Waksman and Henrici, is one of the commonest of diseases affecting the marketable quality of potatoes in Great Britain, little quantitative information has hitherto been available on the extent of the damage caused by the disease, or on its regional, seasonal and varietal distribution. In 1952, Dr. A. R. Wilson of the Agricultural Research Council asked the Plant Pathology Laboratory for survey information on the incidence of the disease for use in connection with research in progress at Sutton Bonington. At that time, the preliminary work on the evolution of a suitable key for Common Scab had already been done at Harpenden on behalf of the N.A.A.S. Disease Assessment Committee. The help of the Potato Division of the Ministry of Food was then sought, and it was decided to take advantage of a "check-weighing" scheme, already in operation by the Potato Division for the estimation of supplies, to obtain supplementary information on the incidence of Common Scab in some 2,500 potato crops in Great Britain each year. These crops were well suited for the purposes of a scab survey, as they were already selected to be as fairly representative as possible of potato crops in each region of Great Britain.

The present paper summarizes the results obtained in 1952 and 1953. The whole of the field work was carried out by Area Officers of the Potato Division; the data concerning scab were extracted and partly analysed from the thousands of record forms at the Statistics Section of the Division at Oxford, and the main part of the analysis was completed at the Plant Pathology Laboratory, Harpenden. For uniformity in the presentation of the results for Great Britain as a whole, the data for Scotland were dealt with in the same way as those for England and Wales, and Dr. T. McIntosh and Dr. C. E. Foister, of the Department of Agriculture for Scotland (Seed Testing, Plant Registration and Plant Pathology Station at East Craigs, Edinburgh), assisted in their interpretation.

SURVEY METHOD

In each field a number of 3-yard sample lengths of drill (varying from eight in a 3–10 acre field to sixteen in a field of 30 acres or more), located according to a random sampling plan, were lifted by hand in late September or early October, before commercial lifting began. The produce from each individual length of drill was graded and weighed, and for the purposes of the scab survey the ware tubers (standing on 1½-inch riddle) were sorted into three categories, according to the proportion of the tuber surface covered by scab lesions, with the aid of the key diagram shown in Fig. 1. The three categories were: (*a*) tubers free from scab or with less than $\frac{1}{8}$ of the surface area affected; (*b*) below $\frac{1}{4}$ but not less than $\frac{1}{8}$ of the surface of the tubers affected; and (*c*) tubers with $\frac{1}{4}$ or more of the surface affected. The mean weight of the ware tubers in each category in each field was returned in terms of tons per acre, together with particulars of the variety, location of the crop, soil type, acreage of the field, and, in 1953, the year in which the field was last ploughed up from grass.

(2064)

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To present the results of the surveys in fairly simple tables and maps it was necessary to choose some level of scab infection at which the crop could be regarded as " substantially affected ". The definition adopted was one already in use for surface diseases of seed tubers in administering a domestic plant health Order, and throughout this paper a " substantially affected " crop means one in which 3 lb. per cwt. ($2\frac{3}{4}$ per cent by weight), or more, of the tubers had scab lesions covering $\frac{1}{4}$ or more of the surface, *or* one in which 50 per cent by weight, or more, of the tubers had $\frac{1}{8}$ or more of the surface covered. This is a relatively low level of infection for ware potatoes. The numbers of crops at other levels of infection are given in Table 1.

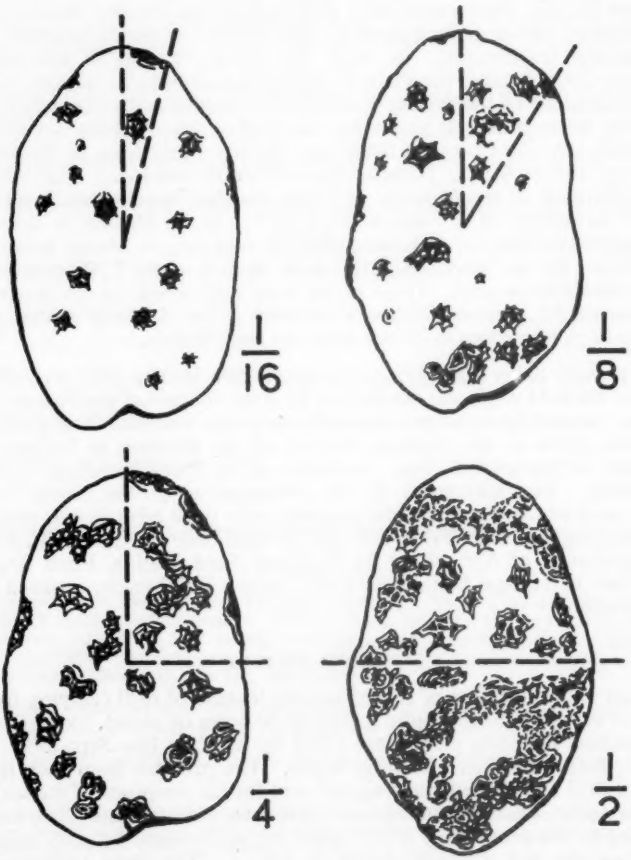

Fig. 1. Key diagram for the assessment of Common Scab on potato tubers. As a guide in estimating the percentage of the tuber surface covered by lesions, the surface may be imagined to be divided into eight equal parts by lines drawn round the tuber in three planes at right angles. A tuber with $\frac{1}{4}$ scab, for example, would then be one in which all the scab lesions, reassembled, would just completely cover two-eighths of the surface. The diagram shows the upper surface of the tuber ; the under surface is assumed to be similarly affected.

Survey of Common Scab of Potatoes

Seasonal Incidence, 1952 and 1953

The total numbers of crops of all varieties included in the survey were 2,556 in 1952 and 2,670 in 1953. The incidence of scab in these crops is analysed in Table 1. In England and Wales 17·8 per cent of the crops were substantially affected in 1952 and 12·4 per cent in 1953; the corresponding figures for Scotland were 5·4 and 3·3 per cent respectively. The figures in Table 1 are arranged cumulatively, so that the corresponding percentages at other levels of infection may readily be seen. The table shows, for example, that in England and Wales in 1952 about 16 per cent of the crops had over 2¾ per cent of the tubers with ¼ or more of the surface covered with scab lesions; about 10 per cent of the crops had over 10 per cent, and about 5 per cent of the crops had over 25 per cent of the tubers so affected.

Table 1

Number of Crops in Survey in Each of Several Categories for Incidence of Scab. All Varieties

Tubers with:	Percentage of Crop	England and Wales 1952 No. of Crops	England and Wales 1952 Percentage	England and Wales 1953 No. of Crops	England and Wales 1953 Percentage	Scotland 1952 No. of Crops	Scotland 1952 Percentage	Scotland 1953 No. of Crops	Scotland 1953 Percentage
¼ Scab or more	Less than ¼ ..	1,191	63·6	1,462	70·6	538	78·8	545	90·8
	Over ¼ ..	682	36·4	608	29·4	145	21·2	55	9·2
	Over 10 ..	454	24·2	320	15·5	34	5·0	16	2·7
	Over 25 ..	288	15·4	161	7·8	14	2·0	7	1·2
	Over 50 ..	139	7·4	80	3·9	3	0·4	7	1·2
½ Scab or more	Less than ½ ..	1,484	79·2	1,748	84·4	598	87·6	573	95·5
	Over ½ ..	389	20·8	322	15·6	85	12·4	27	4·5
	Over 2¾ ..	298	15·9	239	11·5	37	5·4	19	3·2
	Over 10 ..	191	10·2	135	6·5	12	1·8	10	1·7
	Over 25 ..	93	5·0	68	3·3	1	0·1	4	0·7
	Over 50 ..	48	2·6	34	1·6	1	0·1	2	0·3
"Substantially affected"*		334	17·8	257	12·4	37	5·4	20	3·3
Total number of crops..		1,873	100·0	2,070	100·0	683	100·0	600	100·0

* as defined on page 2.

In general, the incidence of scab was considerably lower in 1953 than in 1952, and this was in agreement with the general experience that scab tends to be worse in dry seasons (Moore, 1943). In 1952, June and July were dry months with abnormally high temperatures in most regions; in 1953 these months were in general, cool and wet (see weather notes in this Journal, **2**, 36, and **3**, 32). In the relatively dry season (1952) about 4 per cent of the total yield of ware from all crops surveyed in Great Britain consisted of tubers with ¼ of the surface or over covered by scab: in the wet season (1953) the proportion was only 2 per cent.

Regional Incidence

The location of all the substantially affected crops in each of the two years is shown in Figs. 2 and 3. The total number of crops surveyed in each county is also given on these maps. There were very conspicuous differences in the regional incidence of scab in both years. The areas in which the crops were most severely affected included parts of the North and East Ridings of Yorkshire, East Lincolnshire, Nottinghamshire, Leicestershire, Warwickshire, Staffordshire and Shropshire; and it is noteworthy that these areas coincide

approximately with the Keuper Marl and Bunter Sandstone formations. Other areas in which the incidence appeared high were about the borders of Northumberland and Durham, on the Coal Measures, and to the west of Hampshire on the Greensand.

Apart from a narrow strip in the south of Lancashire, the important ware-growing areas of Lancashire, Lincolnshire, the Isle of Ely, and all the Scottish potato-growing areas were among the least affected.

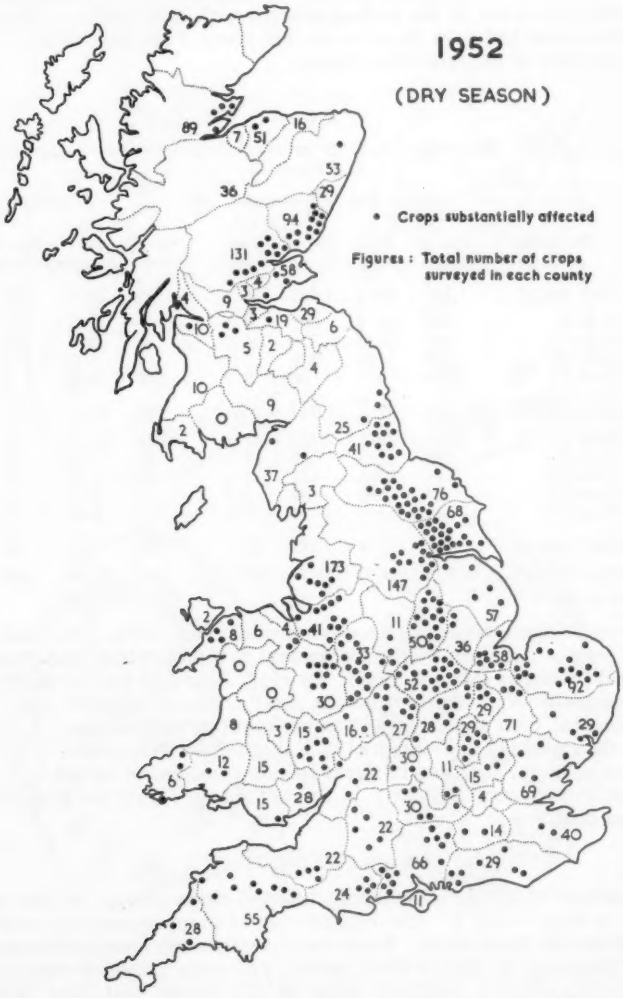

Fig. 2. Location of all substantially affected crops, and total number of crops surveyed in each county, 1952.

The percentages of crops substantially affected in some counties of special interest were as follows :

	1952 *per cent*	1953 *per cent*		1952 *per cent*	1953 *per cent*
Staffordshire	51·5	26·1	Holland, Lincolnshire ..	12·1	3·2
East Yorkshire	48·5	39·1	Isle of Ely	7·7	1·6
Nottinghamshire	28·0	28·8	Perth and Angus ..	9·8	2·6

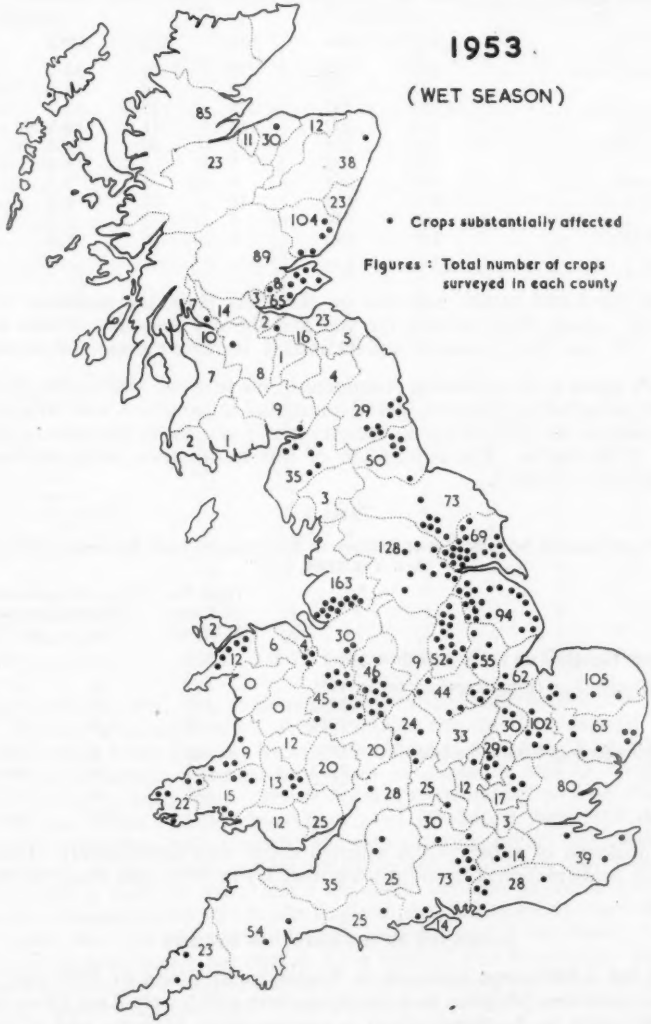

Fig. 3. Location of all substantially affected crops, and total number of crops surveyed in each county, 1953.

In both years the incidence of substantially affected crops was highest on soils reported as " sand and gravel " ; about average on the light, medium and heavy loams ; and lowest on silt, skirt, warp, fen and limestone (Table 2).

TABLE 2

INCIDENCE OF COMMON SCAB IN GREAT BRITAIN IN RELATION TO SOIL TYPE. ALL VARIETIES, 1952 AND 1953

Soil Type	Total No. of Crops in Survey		Crops Substantially Affected by Scab *No.*		*per cent*	
	1952	*1953*	*1952*	*1953*	*1952*	*1953*
Sand and gravel ..	286	244	95	68	33·2	27·9
Chalk	37	23	7	4	18·9	17·4
Medium loam	1,059	1,167	128	115	12·1	9·9
Light loam	384	492	54	41	14·1	8·3
Heavy loam	244	224	47	20	19·3	8·9
Clay	46	35	7	3	15·2	8·6
Limestone	105	88	4	6	3·8	6·8
Silt and skirt	171	198	16	11	9·4	5·6
Warp	65	59	5	3	7·7	5·1
Peat and fen	159	140	8	6	5·0	4·3
All soils	2,556	2,670	371	277	14·5	10·4

On the sand and gravel, and also on the chalk soils, the incidence of scab was about equally high in both the wet and the dry seasons ; it was on the heavier soils that the dry season was inclined to increase the amount of scab.

As scab tends to be unusually prominent in the first two years after grassland has been ploughed up (Moore, 1943), additional information was obtained for all the crops in the 1953 survey on the occurrence of grass in the recent cropping history of the fields. The correlation of this information with incidence of scab is given in Table 3.

TABLE 3

INCIDENCE OF COMMON SCAB IN GREAT BRITAIN IN RELATION TO LAST CROPPING WITH GRASS. ALL VARIETIES, 1953

	Total No. of Crops in Survey	Crops Substantially Affected by Scab *No.*	*per cent*
Fields not ploughed up in the past three years ..	1,688	186	11·0
Fields ploughed up from temporary ley in 1951 ..	447	21	4·7
1952 ..	388	35	9·0
1953 ..	46	10	21·7
Fields ploughed up from old pasture in 1951 ..	41	6	14·6
1952 ..	36	16	44·4
1953 ..	24	3	12·5
All fields	2,670	277	10·4

The incidence of substantially affected crops was considerably above the average in fields ploughed up from temporary ley in 1953, and from old pasture in 1952.

INCIDENCE IN RELATION TO VARIETY

Of all the 3,943 crops surveyed in England and Wales in 1952 and 1953, about one-half were Majestic, and rather less than a fifth were King Edward. Of the 1,283 crops in Scotland, about a quarter were Majestic and a quarter Kerr's Pink. The incidence of scabbed crops in all varieties of which there were 10 crops or more in the survey in each year is shown in Table 4. The

varieties are arranged in order of the mean percentage of crops substantially affected in the two years. The figures for England and Wales and for Scotland are given separately, as some varieties extensively grown in the north are not well represented in the south.

TABLE 4

INCIDENCE OF SCAB IN RELATION TO VARIETY. ALL DISTRICTS, 1952 AND 1953

Variety	Total No. of Crops		No. of Crops having any Tubers with over ⅛ Scab		Crops Substantially Affected by Scab			
					No.		*per cent*	
	1952	*1953*	*1952*	*1953*	*1952*	*1953*	*1952*	*1953*
SCOTLAND								
Redskin	64	63	25	18	6	6	9·4	9·5
Arran Banner ..	12	11	0	2	0	2	0	18·2
Majestic	190	168	64	17	19	5	10·0	3·0
Arran Peak ..	9	11	0	1	0	1	0	9·1
Gladstone	20	17	0	2	0	1	0	5·9
Home Guard ..	18	15	2	0	1	0	5·6	0
King Edward ..	94	88	13	1	4	0	4·3	0
Kerr's Pink ..	165	129	27	11	3	3	1·8	2·3
Arran Pilot ..	26	17	4	0	1	0	3·8	0
Golden Wonder ..	24	31	0	1	0	1	0	3·2
Craig's Royal ..	10	13	1	0	0	0	0	0
Other varieties ..	51	37	9	2	3	1	5·9	2·7
All varieties ..	683	600	145	55	37	20	5·4	3·3
ENGLAND AND WALES								
Dr. McIntosh ..	41	84	14	27	9	19	22·0	22·6
Majestic	964	1,019	419	358	218	149	22·6	14·6
Redskin	121	127	40	57	21	24	17·4	18·9
Arran Consul ..	31	30	12	8	3	6	9·7	20·0
Arran Peak ..	147	117	51	43	22	15	15·0	12·8
Arran Banner ..	115	120	36	33	15	13	13·1	10·8
Dunbar Standard	15	15	5	6	0	3	0	20·0
Gladstone	40	41	14	5	7	1	17·5	2·4
King Edward ..	285	379	67	51	29	17	10·2	4·5
Red King	48	64	6	5	3	4	6·3	6·3
Doon Star	13	17	4	0	3	0	23·1	0
Craig's Defiance ..	11	11	1	0	0	0	0	0
Other varieties ..	42	46	13	15	4	6	9·5	13·0
All varieties ..	1,873	2,070	682	608	334	257	17·8	12·4

The survey showed little evidence of any marked difference in the frequency of occurrence of substantially scabbed crops in the varieties Majestic, Redskin, Dr. McIntosh, Arran Banner, Arran Peak, Arran Consul and Dunbar Standard. There was, however, a consistently lower incidence of scab in King Edward and Red King in both years. There was also some indication from the Scottish figures that Arran Pilot, Home Guard and Gladstone may rank with King Edward, rather than with Majestic, in order of susceptibility to Common Scab. Estimations of the percentage by weight of the total ware crop consisting of tubers with ⅛ scab or over, made for some varieties in 1953, bear out the general indications of Table 4. In England and Wales about 3 per cent of the total yield was thus affected in Majestic, Redskin and Arran Peak ; 2 per cent in Arran Banner, and 1 per cent in King Edward and Red King. In Scotland there was about 1 per cent in Redskin and Kerr's Pink, and nil in King Edward. Among the " other varieties " and varieties of which there were only a few crops (Table 4), there was no evidence of marked freedom from scab, except perhaps in Craig's Defiance. Of the 29 crops of this variety included in the

survey in the two years, none was substantially affected, and only two had any tubers with over ⅛ scab. Definite conclusions cannot, however, be drawn for such a small number of crops. An extensive survey of the present kind, in which crop is grown on a different field, can provide only broad indications of comparative varietal susceptibility ; closer comparisons require field trials.

CONCLUSIONS

The main findings of the survey were, first of all, that the estimation of Common Scab in the field by the method described was straightforward and practical. There was general agreement among all concerned with this work that a tuber with one-quarter of its surface area covered with scab lesions should be regarded as " substantially " (or " objectionably ") affected. The indications of the surveys, so far, are that when the months of June and July are dry, about 4 per cent of the national potato yield in Great Britain may be composed of such tubers ; whereas when this period is cool and wet, the proportion may be about 2 per cent. It is possible that there may be more than 4 per cent in years when the whole summer is exceptionally hot and dry, as in 1947 and 1949. More evidence will, however, be obtained from the 1954 and later crop surveys. In the relatively dry season (1952) about 16 per cent of the crops in England and Wales had 3 lb. per cwt. or more of the tubers ¼ covered by scab ; in an additional 2 per cent there were fewer tubers ¼ covered, but a large number of tubers (over 56 lb. per cwt.) were ⅛ covered. In Scotland, in the same year, only 5·4 per cent of the crops had 3 lb. per cwt. or more of the tubers ¼ covered, and this included the few crops having 50 per cent of the tubers with over ⅛ scab. A very valuable contribution from the survey was the indication (Table 1) of the proportion of the crops that would be included or excluded at various levels of scab tolerance.

The surveys showed that when the economic significance of Common Scab is considered, it should be borne in mind that the disease tends to be more severe when potatoes are short after a dry season, than when supplies are abundant after a season with plenty of rain.

Common Scab occurs in all parts of Great Britain, but the incidence is highest in parts of Yorkshire and the East and West Midlands, and lowest in Scotland, most of Lancashire and the Fens. The disease is *not* most severe where most of the potatoes are grown. The surveys have borne out the past experience that scab tends to be worse on the light, sandy or gravelly soils, and on land recently ploughed up from grass. Considerably less scab was found on King Edward than on Majestic, and although in part this may reflect the fact that King Edward tends to be grown on the better potato land, there is an indication that the maincrop varieties most extensively grown in Great Britain fall into two groups for order of susceptibility to scab—one group being typified by Majestic and the other by King Edward. The surveys are continuing.

Thanks are due to all the Area Officers of the Potato Division of the Ministry of Food who carried out the careful gradings and weighings on over 5,000 crops in the course of these surveys.

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THE MUSHROOM PHORID FLY EPIDEMIC OF 1953

by B. D. MORETON AND MARGARET E. JOHN

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The Phorid flies occurring in cultivated mushroom beds have been little investigated, and before 1953 the only well-known species was *Megaselia* (*Megaselia*) *nigra* (Mg.) (syn. *M. albidihalteris* (Felt.)), the larvae of which occasionally tunnel the caps and stems, particularly during the summer months. In 1953 attention was drawn to another species, provisionally identified by Mr. C. N. Colyer as *Megaselia* (*M.*) *plurispinosa* (Lundbeck). Some of the flies sent to Mr. Colyer resembled *Megaselia* (*M.*) *halterata* (Wood), and it appears not improbable that *M. plurispinosa* and *M. halterata* are one variable species (Colyer, 1954).

Phorid flies, probably *M. plurispinosa*, have been familiar in small numbers to Worthing mushroom growers for several years, but it was not until their occurrence on an unprecedented scale in 1953 that they were investigated. *M.* (*M.*) *halterata* var. *plurispinosa* was referred to by Broekhuizen (1938) as a pest of mushrooms in Holland. Both forms have been known as common species in Britain for some forty years, although *M. plurispinosa* has only been found in glasshouses and similar situations.

The 1953 infestations coincided with the development along parts of the south coast of remarkably large numbers of the shore fly, *Coelopa frigida* F., and the seaweed-inhabiting Borborids. The Phorids were first noticed in May and June, and from July onwards rivalled the shore flies in numbers, occurring in thousands on most of the mushroom-growing nurseries in the area in and near Worthing. After repeated insecticidal treatments, the insects blackened the floors of sheds, in one case choking ventilator fans, and they also became a nuisance in houses. Presumably owing to the continuance of mild, humid weather, large numbers persisted into December and were still present on some nurseries until the hard cold spell in February. Outside the concentration in West Sussex, mushroom growers are fewer and more scattered, and many escaped trouble in the other south-eastern counties ; heavy infestations occurred at Harrietsham, Doddington and Belvedere in Kent, at Putney and Compton in Surrey, while none was reported from East Sussex. In other counties the only serious infestations recorded were at Formby, Lancs (specimens sent by Mr. S. P. Simmonds, N.A.A.S., Leeds) and Thornham, Norfolk (specimens sent by Dr. R. L. Edwards, Mushroom Research Station, Yaxley). Reports received in August 1954 showed that the flies were again extremely abundant on a number of Worthing nurseries, and in September and October three nurseries in Surrey and East Sussex, which had been free in 1953, became heavily infested.

No explanation for the exceptional abundance of the fly has been found, though this may have been associated with the humid summer of both 1953 and 1954, which perhaps increased the extent of its natural breeding grounds. Its distribution is also puzzling, particularly the existence of heavy infestations at three isolated farms in Kent while others, a few miles away, remained free from trouble. The sudden occurrence in 1947 of large numbers of *M. halterata* in a house in the New Forest is described by Colyer (1954).

The larvae of *M. plurispinosa*, although described in Holland as tunnelling in mushroom stems, have so far in Britain been characteristically confined to

the compost, where they presumably feed upon the mycelium. Mushrooms are usually grown in specially composted straw and horse manure, which, before the fermentation process has ended, is made into beds or filled into boxes, and is then allowed to heat up to 120–140° F. for periods varying from 8 hours to a day or longer. This pasteurising process, known as " peak-heating ", can be assumed to render the compost free of fly infestations. When the temperature has fallen sufficiently, the compost is inoculated with mushroom " spawn ", from which mycelium grows into the compost. Flies frequently laid eggs in or near the spawn, and where larvae became numerous enough, they prevented development of the mycelium, causing complete crop failure.

When larvae became abundant at later stages, the partial destruction of mycelium led to varying degrees of crop reduction. Disastrous failures were common, but it is difficult to assess losses due to the Phorid, for subsequent developments have suggested that troubles associated with the widespread adoption of a peat and chalk casing mixture instead of soil, in the latter part of 1953, were to some extent responsible for the poor crops. Laboratory experience has indicated that the compost may support large numbers of larvae—perhaps as many as 1,000 per square foot in a bed six inches deep—without a marked effect on the mushroom crop.

ATTEMPTS AT CONTROL

Attempts at control met with little success. The usual fumigation with BHC, DDT or parathion smokes, or dusting the beds with 5 per cent BHC dust at ½–1 lb. per 1,000 sq. ft. between spawning and casing, and again after casing, proved inadequate. An application of 5 per cent BHC dust at ½ lb. per 1,000 sq. ft., was made daily for three weeks by one grower, but it failed to prevent infestation of the beds. The most effective practice appeared to be the mixing of 5 per cent BHC dust with the compost at 6 lb. per ton just before filling the beds and peak-heating, followed by dusting of the beds and environs of the buildings with 20 per cent DDT wettable powder at 2 lb. per 1,000 sq. ft., alternating with 5 per cent BHC dust at ½–1 lb. per 1,000 sq. ft., each once a week. Such heavy use of DDT is not officially recommended. Malathion, as aerosol or 0·1 per cent spray, was also found useful by some growers.

The mixing of 5 per cent BHC dust with the compost at 6 lb. per ton was claimed by some growers to give protection over the critical spawn-running period, and in laboratory experiments in the spring of 1954 this treatment appeared to result in a considerably reduced infestation for the 3 or 4 weeks following spawning. However, in further experiments in the summer of 1954 with the same fly population, composts with which the dust was mixed at 10 lb. per ton *after* peak-heating (when there would be no losses due to high temperatures) became as heavily infested in the ensuing 3 weeks as untreated composts. Treatment with 1½ per cent aldrin dust at 3 lb. per ton was likewise ineffective, but 5 per cent malathion dust at 1 lb. per ton resulted in a much reduced infestation for 3 weeks, and at 4 lb. per ton gave almost complete control for 8 weeks. None of the treatments affected the growth of the mycelium.

Because of its failure to give control, it was widely held that the flies had become resistant to BHC, especially because within a few hours of treatment with smokes or *gamma*-BHC aerosols at two or three times the normal rate the Phorids were still flying in great numbers. Such resistance is possible, although failure to gain control may have been largely due to the enormous numbers of the flies and the normally slow action of insecticides like BHC.

Flies exposed to dry deposits on bolting-silk sleeves from emulsions of 0·01 per cent *gamma*-BHC, 0·1 per cent DDT and 0·015 per cent dieldrin all died, but mortality was not complete until after 8 hours or even longer. The 0·1 per cent malathion, however, gave a complete kill in 2 hours and deposits were still effective a week later.

Malathion is promising, both mixed with compost and as a spray applied to the building and beds immediately after spawning, and again several times at weekly intervals. Although it appears to have no adverse effect on mushroom growth, and no off-flavour has been noticed, it is still not known whether any is absorbed by the mushroom. It is desirable that more attention should be devoted to the problems of "fly-proofing" houses, especially during the three weeks while the spawn is running and when ventilation is not so important. Owing to all the difficulties involved, many of the Worthing glasshouse growers gave up growing mushrooms during the summer of 1954.

The flies have been reared in the laboratory by keeping pairs in 3 inch × 1 inch glass tubes closed with gauze and containing a small quantity of mushroom spawn. The life cycle under these conditions occupied 6–8 weeks in winter and 3–4 weeks in summer, and about 40 progeny were reared from each pair.

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COMPARISON OF ALDRIN AND BHC FOR THE CONTROL OF CARROT FLY

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The control of Carrot fly, *Psila rosae* F., with BHC has become a standard horticultural practice, well illustrated by the work of Newton, Satchell and Shaw (1946), Wright (1950, 1953) and Shaw (1952). A trial was carried out at Craibstone in 1952, within the Horticultural Department of the College of Agriculture, to compare the effectiveness of *gamma*-BHC, crude BHC, and aldrin, each with an oil spray for the control of weeds.

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The trial was made on carrots of the variety Early Market sown on April 19 and May 15, 1952. The rows were 18 inches apart and 12 yards long, with a buffer row between each of the treated rows. In an experimental layout consisting of two sets of six randomized blocks, the following five treatments were each applied on twelve rows :

Aldrin with weed oil	8 oz. aldrin plus 40 gallons weed oil per acre.
Gamma-BHC with weed oil ..	8 oz. *gamma*-BHC (99 per cent *gamma*-BHC) plus 40 gallons weed oil per acre.
Gamma-BHC after weed oil ..	1 oz. 0·45 per cent *gamma*-BHC dust per six yards of row (surface dressing) following application of weed oil at 40 gallons per acre.
Crude BHC after weed oil ..	1 oz. 3½ per cent crude BHC dust (12½ per cent *gamma*-BHC content) per six yards of row (surface dressing) following application of weed oil at 40 gallons per acre.
Weed oil alone	40 gallons weed oil per acre (Shell weed-killer W).

The treatments were applied to the April-sown carrots on May 26, the day following the first catch of adult carrot flies on sticky traps placed among the carrots. On the May-sown carrots the applications were carried out on July 1, when growth had reached the second rough-leaf stage. All the plots received the usual inter-row cultivations.

For the assessment of Carrot fly damage, the carrots from four yards of each row were lifted, washed and graded between November 3 and December 12, 1952. The categories used in the grading were " clean " (no visible larval mines), " slight " (1–3 visible larval mines on the root), " moderate " (4–6 larval mines), and " unsaleable " (over 6 larval mines). A total of about 1,000 roots were graded for each treatment from each sowing, and the mean percentages found in each class were as follows :

	Carrots Sown April 19				Carrots Sown May 15			
	Clean	*Slight Attack*	*Moderate Attack*	*Unsaleable*	*Clean*	*Slight Attack*	*Moderate Attack*	*Unsaleable*
Aldrin with weed oil	36	41	17	6	43	41	10	6
Gamma-BHC with weed oil ..	77	21	2	0	68	30	2	0
Gamma-BHC after weed oil ..	57	36	5	2	69	27	4	0
Crude BHC after weed oil ..	84	14	1	1	81	18	1	0
Weed oil alone ..	17	36	27	20	19	32	19	30

From an analysis of transformed values, the following differences among the percentages of clean carrots were found to be significant : the result for aldrin with weed oil was poorer than that for *gamma*-BHC with weed oil in each sowing ($P<0·001$) ; the result for *gamma*-BHC after weed oil was poorer than that for *gamma*-BHC with weed oil in the April sowing only ($P<0·01$) ; the result for crude BHC after weed oil was better than that for *gamma*-BHC with weed oil in the May sowing only ($P<0·05$) ; and the result for weed oil alone was poorer than that of any of the other treatments, with the exception of the result for aldrin in the first sowing ($P<0·001$).

Further liftings of the May-sown carrots, made on February 2, 1953, gave evidence of continued damage. The percentage of clean carrots varied from 61 per cent for crude BHC after weed oil and 51 per cent for *gamma*-BHC with weed oil to 19 per cent for weed oil alone.

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It will be seen that the BHC treatments proved highly effective in controlling attack by first generation Carrot fly. The aldrin treatment was also effective, but much less so than the BHC—a result in agreement with the finding of Wright (1953). Among the BHC treatments, the best results were obtained by using 3½ per cent crude BHC, but results scarcely inferior were obtained with *gamma*-BHC applied simultaneously with weed oil. The slight advantage of the former would not appear to warrant its use in view of the ease of application of the *gamma*-BHC and weed oil combination and the possibility of taint by use of the crude BHC.

New Zealand Department of Agriculture

We thank Dr. G. D. Morison for his interest and advice; Mr. J. Panton for facilities within the Horticultural Department at Craibstone; Dr. W. Moore for help with the aldrin and *gamma*-BHC treatments; and Mr. D. Walker and Mr. A. Petrie for their help in the field.

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APHID TRANSMISSION OF CAULIFLOWER MOSAIC ON TURNIPS

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Detailed descriptions have been published of the effects of cauliflower mosaic virus in broccoli (Caldwell and Prentice, 1942; Broadbent and Tinsley, 1953), but little is on record concerning its effects on its other common hosts. In this paper symptoms on turnip (*Brassica rapa* L. var. Early Snowball) are described, together with the results of transmission experiments with two aphid vectors, *Myzus persicae* (Sulz.) and *Brevicoryne brassicae* (L.).

The first symptom of infection in turnip plants is a clearing of the veins on the young leaves, which passes into vein-banding or general mottling with necrotic spots. The mottling is often unevenly distributed and growth of the tissues between the necrotic patches causes crumpling and distortion of the leaves.

Isolates of cauliflower mosaic virus from different plants caused different symptoms in turnip. One isolate from turnip caused only a mild mosaic in var. Early Snowball, but isolates from cabbage and cauliflower produced severe diseases. The outer leaves died leaving only a stump of unexpanded parsley-like leaves in the centre of the plant.

In the glasshouse, symptoms usually take 2–4 weeks to appear and their development varies with the age of the plant and conditions of growth. Young turnips are sometimes killed, whereas older plants may only show necrotic or chlorotic local lesions. Applying fertilizers two to three weeks after potting influenced the expression of symptoms and also the growth of the plants. Nitrogen plus phosphate and potash produced plants with large dark-green leaves that showed severe mottles with necrotic spots (Plate I, 2). Plants that received only phosphate were readily infected but showed slight symptoms, while potash alone produced small and " hard " plants that either showed no leaf symptoms or a very mild mottle. Plants that received no fertilizers were small with pale leaves, and symptoms were indefinite (Plate I, 1).

TRANSMISSION BY MYZUS PERSICAE AND BREVICORYNE BRASSICAE

Stock cultures of the virus were kept in turnip plants and all transmission tests were done using young seedlings. The aphids were reared and handled according to the methods described by Watson (1936, 1938), and the special terms referring to the techniques are as follows :

Preliminary fasting time	a period without food before infection feeding.
Infection-feeding time	a period during which an aphid feeds on an infected plant.
Test-feeding time	a period during which an aphid feeds on a healthy plant after infection feeding.
Post-infection fasting time ..	a period without food after infection feeding.

With non-persistent viruses, such as potato virus Y (Watson and Roberts, 1939), sugar beet mosaic virus (Watson, 1946) and cabbage black ring spot virus (Hamlyn, 1953), a period of preliminary fasting and a short feeding time on an infected leaf increases the efficiency with which *M. persicae* will transmit the disease to healthy plants. The transmission of cauliflower mosaic virus by the two aphid vectors, *M. persicae* and *B. brassicae* in some ways resembles that of these other viruses, but there are some interesting differences.

To find the effect of preliminary fasting on transmission, *M. persicae* were fasted for 0, 5, 15, 30 and 60 minutes before 2 minute infection-feeding time. Two aphids per plant were tested. Out of a total of 35 plants colonized with aphids receiving the different fasting times, 5, 5, 10, 15 and 11 plants became infected. There is evidence of some response to fasting times of 15 minutes and 30 minutes, but the response is smaller than that obtained with most other non-persistent viruses.

Another characteristic of the transmission of non-persistent viruses is that aphids which are kept without food after infection-feeding remain infective for longer than if they are allowed to feed continuously. For example, with cabbage black ring spot virus (Hamlyn, 1953) some aphids which were starved for 6 hours after their infection feed still caused infections when placed on a healthy test plant. However, if aphids were moved consecutively every 5 minutes during a 1-hour test-feeding period, most infections were produced during the first 5 minutes, and after 35 minutes the aphids rarely caused infection. To find whether post-infection fasting had a similar effect on the transmission of cauliflower mosaic virus, aphids were starved for 0, 1, 2, 4 and 6 hours after 24 hours infection-feeding time. They were then placed on the test plants. Table 1 shows that the number of infections dropped to approximately half after 1 hour, but then decreased only slowly and more than a quarter as many were still obtained after 6 hours.

TABLE 1

EFFECT OF VARYING POST-INFECTION FASTING TIMES ON THE TRANSMISSION OF CAULIFLOWER MOSAIC VIRUS BY MYZUS PERSICAE

Two aphids per plant. Infection-feeding time 24 hours. 30 plants per treatment.

	Post-infection Fasting Times (hours)				
	0	*1*	*2*	*4*	*6*
Number of infected plants ..	18	8	7	8	5

To see how long feeding aphids remain infective with cauliflower mosaic virus, *M. persicae* were given infection feeds of 2 minutes, 1 hour and 24 hours and placed on the test plants, where they remained for periods of 10 minutes, 30 minutes or 3 hours. They were then removed to fresh plants and left on for 24 hours. This tested the duration of the infectivity of *M. persicae* after varying test-feeding periods. The results (Table 2) indicate that the length of the infection-feeding times had little effect on transmission and that *M. persicae* can still transmit cauliflower mosaic virus after being on a susceptible plant for 3 hours. This ability to remain infective for at least 3 hours in the feeding vector distinguishes cauliflower mosaic virus sharply from non-persistent viruses previously studied. Such increased persistence may be partly responsible for the fact that cauliflower mosaic virus spreads more extensively in the field than cabbage black ring spot virus, which rarely persists for longer than 35 minutes when the vector is feeding on healthy plants.

TABLE 2

EFFECT OF VARYING INFECTION-FEEDING AND VARYING TEST-FEEDING TIMES ON THE TRANSMISSION OF CAULIFLOWER MOSAIC VIRUS BY MYZUS PERSICAE

Three aphids per plant. Preliminary fasting time 16 hours. 40 plants per treatment.

Test-feeding Times	Infection-feeding Times		
	2 minutes	*1 hour*	*24 hours*
First series			
10 minutes	9	11	5
30 minutes	6	4	9
3 hours	9	12	6
Second series			
24 hours	3	6	3
24 hours	3	3	2
24 hours	7	2	3

Tests were made to find the optimum time required by *M. persicae* and *B. brassicae* to acquire cauliflower mosaic virus. Previously fasted aphids were given short feeding times ; namely, 30 seconds, 2 minutes, 5 minutes, and 15 minutes. When given 2 minutes, 5 minutes, and 15 minutes feeding, both vectors transmitted the virus to about the same proportion of test plants (Table 3). With infection feeds of 30 seconds, both transmitted less frequently, but *M. persicae* infected twice as many plants as *B. brassicae*.

TABLE 3

EFFECT OF VARYING INFECTION-FEEDING TIMES ON THE TRANSMISSION OF CAULIFLOWER MOSAIC VIRUS BY MYZUS PERSICAE AND BREVICORYNE BRASSICAE

Two aphids per plant. Preliminary fasting time 4 hours.

	Infection-feeding Times (minutes)							
	Myzus persicae				*Brevicoryne brassicae*			
	½	*2*	*5*	*15*	½	*2*	*5*	*15*
Percentage of plants infected	13	22	23	23	7	25	20	20

A considerable difference was noticed between the feeding behaviour of *M. persicae* and *B. brassicae* after they had fasted. When placed on a leaf,

M. persicae made several punctures of short duration after 20–30 seconds, but several minutes often elapsed before *B. brassicae* made any puncture. *B. brassicae* usually remained feeding in one position for longer than *M. persicae*. However, this difference in the feeding behaviour of the two aphids did not seem to influence their efficiency as vectors. *M. persicae* and *B. brassicae* were compared in another experiment in which infection-feeding times of 2 minutes and 24 hours were given. The effect of 4 hours preliminary fasting and no preliminary fasting was also compared (Table 4). On this occasion there appeared to be no response to preliminary fasting, and no difference, within the accuracy of the experiment, between 2 minute and 24 hour feeding.

TABLE 4

EFFECT OF PRELIMINARY FASTING AND VARYING INFECTION-FEEDING TIMES ON THE TRANSMISSION OF CAULIFLOWER MOSAIC VIRUS BY MYZUS PERSICAE AND BREVICORYNE BRASSICAE

Two aphids per plant.

	Infection-feeding Times			
	No Preliminary Fasting		4 hours Preliminary Fasting	
	2 minutes	*24 hours*	*2 minutes*	*24 hours*
Percentage of plants infected				
M. persicae	22	34	22	25
B. brassicae	31	38	25	25

One of the striking findings from these experiments with cauliflower mosaic virus was that both within and between experiments the number and distribution of infected plants varied considerably. On some occasions a period of preliminary fasting increased the amount of infection obtained when *M. persicae* were given a short infection feed, but on other occasions preliminary fasting had no influence on transmission. The time taken by *M. persicae* to acquire cauliflower mosaic virus varied from 30 seconds to 24 hours, and successful transmissions occurred after 3 hour test-feeding. This irregular behaviour of cauliflower mosaic virus distinguishes it from other viruses of the non-persistent type. Similar experiments made on previous occasions with cabbage black ring spot virus (Hamlyn, 1953), using the same vector and the same host plant, gave no such irregularities. It must be concluded from this that the irregularity is an attribute of cauliflower mosaic virus itself, and not directly of the host or vector.

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1. Symptom expression on var. Snowball grown without fertilizers. *Left :* healthy plant. *Right :* inoculated plant, showing small pale leaves with indefinite chlorotic effects.

Photos : Rothamsted Experimental Station

2. Symptom expression on the same variety when full N, P, K fertilizers were given. *Left :* healthy plant. *Right :* inoculated plant, showing crumpling of the leaves accompanying severe mottle and necrotic spotting.

PLATE I

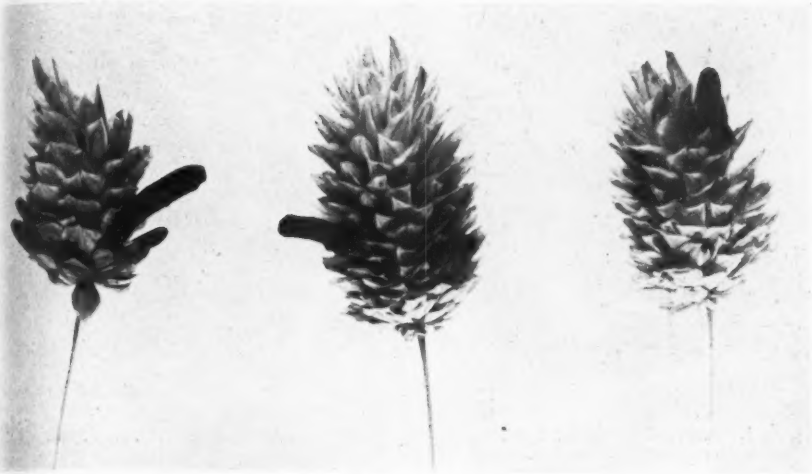
FRIT FLY DAMAGE ON WHEAT (see *p.* 32)

1. **Extensive damage at tip of ear giving whip tail effect.**

2. Torn glumes at tip of ear with pupae *in situ.*

PLATE II

ERGOT ON CANARY GRASS (*see p. 32*)



1. Seed heads of *Phalaris canariensis* showing typical ergots.

FLOWER SCORCH OF CHRYSANTHEMUM (*see p. 33*)

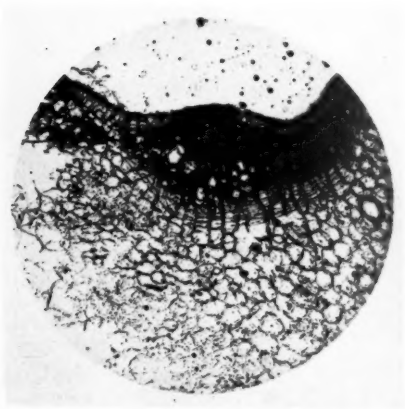
2. Bloom showing typical attack on florets.

PLATE III

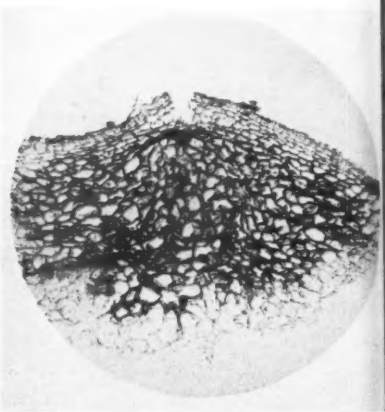
1. Normal form of Skin Spot.

2. Abnormal form of Skin Spot.

3. Section of tuber showing abnormal depth of lesions.



4. Section through normal lesion showing well-developed underlying barrier of cork cells.



5. Section through abnormal lesion showing absence of cork barrier and deeper penetration

PLATE IV

AN ABNORMAL FORM OF SKIN SPOT ON POTATOES

by JUNE V. IVES

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In March 1951, two samples of ware tubers affected with an unusual form of Skin Spot, *Oospora pustulans* Owen and Wakef., were received from Soham and Waldersea in Cambridgeshire. The individual lesions were larger and deeper than those normally associated with the disease, many being as much as 1 cm. in diameter and 6 mm. deep (Plate IV, 1, 2 and 3). The injury was so severe that the tubers were rendered unfit for sale. In the clamp of Majestic at Soham almost every tuber was affected, while in the clamp of King Edward at Waldersea nearly half of a twenty-ton lot was spoiled. In both cases the tubers had been treated at lifting with a dust containing *iso*propyl phenyl carbamate (IPC) to delay sprouting. Clamps of untreated potatoes on both farms were said to show no signs of the trouble.

During the spring of 1952 some twenty further samples, representing well over 1,000 tons of potatoes, were sent in from various parts of the Eastern Province : all showed similar symptoms. In every case the same sprout suppressor had been used, and from the lesions *O. pustulans* developed on incubation. There were some clamps having portions made up of IPC-treated and untreated tubers from the same fields, and in these the treated tubers had abnormal lesions, while the untreated had lesions of the normal type. The varieties affected were chiefly King Edward and Majestic, but Red King and Conference were also involved.

Attempts were made to reveal possible anatomical differences between the abnormal and normal lesions, and to ascertain whether the IPC was causing tissue breakdown in conjunction with the fungus, or enabling the fungus to develop to a greater extent than normal in the tissues.

ANATOMICAL OBSERVATIONS

In 1952, freehand sections were cut through normal Skin Spot lesions on several varieties of potatoes, and these were compared with similar sections cut through the abnormal lesions. In the normal lesions there was, in general, a cup-shaped layer of cork cells between the diseased and the deeper, healthy, tissue (Plate IV, 4). Owen (1919) found that this layer was not always present, but my observations were in agreement with those of Millard and Burr (1923), who found that in normal Skin Spot lesions the cork layer delimiting the lesion was not always well developed, but it was never entirely absent.

The sections of abnormal lesions, however, were generally markedly different from the normal, in that the cork layer was either entirely lacking or very thin and incomplete (Plate IV, 5). Sometimes a layer appeared to have been formed in the normal position—some ten cells below the periderm at the deepest point—but the fungus had broken through the barrier and invaded the cells beyond it. In other sections there were " islands " of uninvaded cork cells at random in the lesion. The infected cells appeared larger than those in normal Skin Spot lesions, partly owing to absence of compression, and partly because the fungus occupied cells deeper into the tissue than normal. They were, in fact, of about the same size as the surrounding cortical cells. The hypae of *Oospora* could readily be seen within them. The lesions were often as much as 35 cells deep,

but there appeared to be a limit to the penetration of the fungus, for even in specimens examined one year after the IPC treatment no lesions that had not suffered secondary rotting were found to have penetrated deeper than 1 cm.

EFFECT OF STORAGE TEMPERATURE

An attempt was made to reproduce the apparent effect of IPC on tubers infected with Skin Spot. Healthy Majestic and King Edward tubers from Wisbech were inoculated on December 19, 1952, with *O. pustulans* from culture, by introducing the fungus into small incisions. Some of the inoculated tubers were treated on December 22 and others on December 29, with commercial IPC at the normal rate (0·5 gm. per lb. of tubers of a preparation containing 2·4 per cent IPC), while further tubers were left untreated. Similarly, King Edward tubers from a farm in Scotland, on which Skin Spot was known to have been troublesome in the past, but which were not yet showing symptoms, were also treated. All the tubers were stored in moist peat, half of those for each treatment at 42° F., and the other half at 53–87° F.

Sections were cut through inoculated areas, selected Skin Spot lesions, or through wounds, according to treatment, after 33, 104 and 179 days of storage under these conditions. The maximum depths, in number of cells, of the infected or suberized layers and of the cork layers were recorded, and observations were made on the nature of the cork layer.

At no time, at either storage temperature, did the presence of IPC have any macroscopic effect on the size of the lesions. Under the cooler storage conditions cork was very slow to form and often failed to develop at all. In the King Edward tubers, both those from Scotland on which Skin Spot had developed naturally, and the inoculated ones, the cork layer was very irregular and shallow, or, more often, absent, and it was no better formed beneath the lesions in untreated tubers than in those treated with IPC. In Majestic the layer failed to develop beneath the lesions in inoculated treated tubers, and on the untreated it was also absent or, at best, irregular. In the tubers stored under the warmer conditions cork was rarely absent under the lesions in tubers of either variety, but it tended to be much more irregular both in outline and in depth where the tubers had been treated with IPC. The fungus penetrated a few cells deeper, on average, after the cooler storage than after the warmer. With warmer storage, in all three samples, it was rather deeper on the treated tubers than on the untreated, whereas there was no appreciable difference in the depth of the lesions between treated and untreated tubers with cooler storage.

Thus it seemed that IPC had some hindering effect on the development of the meristematic layer following infection with *Oospora*. It was also clear that low temperature could have a similar effect. Neither IPC nor low temperature appeared to have any adverse effect on the progress of the fungus in the cells. In no case was there any discernible effect from IPC on cuts already healed over before its application.

EFFECT OF STORAGE HUMIDITY

Some of the King Edward tubers from Scotland were used in an experiment to ascertain whether the abnormal symptoms could be reproduced if the tubers were stored under humid conditions. On December 30, 1952, two 10 lb. lots of the tubers, one treated with IPC at normal rate, the other untreated, were put in sacks and both were kept damp. For comparison, other lots of the treated and untreated tubers were stored in large desiccators, the tops of which were

lifted occasionally for ventilation. All four samples were kept at 45° F. After eight weeks Skin Spot had developed on 20 per cent of the tubers stored in the damp sacks and on 11 per cent of those in the desiccators. The lesions were of normal size and there was no macroscopic effect of IPC treatment. After fifteen weeks, by mid-April, there was Skin Spot on 69 per cent of the tubers stored in the sacks and on 53 per cent of those in the desiccators. The amount of Skin Spot in both untreated and treated samples was about the same.

FIELD TRIALS IN 1952–53

In April 1952, King Edward ware tubers that had been treated with IPC and showed the abnormally large Skin Spot lesions, were interplanted on a plot at Anstey Hall, Trumpington, with healthy King Edward seed tubers from another source. Two small seed tubers were placed one on either side of each infected ware tuber, each group of three tubers being 15 inches apart along the rows, with 3 feet 6 inches between them. The land was ploughed up from old grass in 1950 and this was the first crop of potatoes to be grown on it ; the soil was an organic sandy loam.

The progeny from the healthy seed tubers and the infected ware tubers were lifted separately on four dates between September 1 and October 30, 1952. The crop from the diseased tubers was negligible, but the remains of the mother tubers were collected and the skins were incubated. Often the tubers were considerably decomposed, and sometimes all that remained was the skin with a little of the underlying tissues where there were Skin Spot lesions. Only a few tubers were intact. It was of interest that 48 per cent of these old tubers gave rise to *O. pustulans* from Skin Spot lesions within a few days, indicating that the mycelium was still alive in the tissues.

From the tubers obtained from the healthy sets at each lifting date two 56 lb. lots were weighed out, one of which was treated with IPC at the normal rate on November 4, and the other left untreated as control. All the eight samples were stored, half of each sample in sacks and half in trays, in a cool room at an average temperature of 45° (35–70°) F.

No Skin Spot was noted on any of the tubers at lifting and none had developed by mid-February, 1953. By the end of April, however, Skin Spot was present on some 30 per cent of the tubers, and after another month the amount had increased slightly. A few large spots were found in both treated and untreated samples, but the majority of the spots were normal, and there was nothing resembling the abnormal Skin Spot on the affected mother tubers that had been planted. The percentages of the tubers showing Skin Spot in each of the eight samples at the end of April, and at the end of May were as follows :

Date of Lifting, 1952	Untreated Tubers		IPC-treated Tubers	
	End of April	End of May	End of April	End of May
	per cent	*per cent*	*per cent*	*per cent*
September 1	—	—	19	20
September 23..	31	38	30	31
October 10	34	34	44	48
October 30	31	35	51	56

Among the untreated tubers the date of lifting had no effect on the amount of Skin Spot—an observation in agreement with that of Greeves and Muskett (1939). Among the IPC-treated tubers, however, there was evidence of progressively greater development of Skin Spot from the earlier to the later liftings, the ultimate amount of spotting being considerably more than in the untreated controls.

EFFECT OF IPC ON THE HEALING OF WOUNDS IN TUBERS

Olufsen (1903), Priestley and Woffenden (1923), Werner (1938) and others have found that wound cork is formed slowly at low temperatures, whereas at higher temperatures suberization and production of a cork layer proceeds more rapidly. Sanford (1951) demonstrated that in a moist soil calcium hydrate and chloranil accelerated the wound-healing process, while Cunningham (1953) showed that the methyl ester of naphthaleneacetic acid and tetrachloronitrobenzene delayed or even inhibited it. Attempts were therefore made to ascertain the direct effect of IPC on the healing process.

Closed jars containing small Majestic tubers, washed, dried and halved, were kept at 42° F. and 70° F. In some, IPC was dusted, at approximately the normal rate, on to the cut surfaces ; in others, IPC, in about the amount required for the weight of tubers, was suspended over the tubers in a watch glass ; in others, the cut surfaces of the tubers were dusted with talc, using about the same amount as of IPC dust. The remainder were controls. Half of the tubers in each treatment were maintained in a moist atmosphere and the other half were kept dry. The jars were opened from time to time for ventilation.

After 26 days at 42° F. most of the tubers remained firm, and in none of the treatments was there any trace of cork formation. Suberization was absent or, as in the two non-dusted treatments, not more than 1 cell deep. After 56 days at this temperature suberization was never more than 3 cells deep in any treatment. A cork layer was still absent in the two IPC-dusted treatments, the moist vapour treatment and the dry control ; but it was present and irregular in the dry vapour treatment and the moist control.

After 26 days at 70° F. there was a slight development of suberin, one or two cells deep, in all treatments. In the dusted IPC treatments and the moist vapour treatment cork was lacking, and in the dry vapour treatment it was very slight and irregular ; but in the talc and untreated tubers it was up to three cells deep and never entirely absent. The presence of mould growths on the cut surfaces after 56 days precluded reliable observations, but there was evidence in the sections that the tubers dusted with IPC were producing a narrow, irregular, broken band of cork beneath the cut surfaces.

In a further experiment the same treatments were applied to cut halves of large Majestic tubers kept in strawboard boxes. In the " dry " series all the tubers were open to the atmosphere, except those in the vapour treatment, which were covered with two layers of brown paper. In the " moist " series the boxes were kept under moistened sacks. All were at room temperature. Sections were cut after 23 and 84 days. Suberization occurred with all treatments and was generally three cells deep, with occasional shallower areas in some sections. A cork layer was absent from the IPC-treated surfaces even after twelve weeks, and it was present but irregular in both the vapour treatments after 23 days ; after 84 days it was still irregular in the moist but regular in the dry vapour treatment. Once more talc had no effect on the healing process, and cork layers formed normally both in the talc-treated and the control tubers.

The general indications from the experiments on healing of wounds were : that IPC did not affect suberization, whereas temperature influenced both its rate of formation and its depth ; that where the IPC was applied directly to a cut surface a cork layer either did not form or developed very slowly ; that where IPC was placed near, but not in direct contact with, a cut surface it had a rather retarding effect on cork formation in a damp atmosphere, but the

healing process was more normal at a lower humidity ; and, finally, that the use of talc on the cut surfaces caused no disturbance to the normal healing process.

DISCUSSION

Although the abnormal Skin Spot symptoms found on IPC-treated ware tubers in 1952 were not successfully reproduced, the experimental results obtained have indicated that IPC is capable of retarding the formation of a cork layer under Skin Spot lesions or cut surfaces.

Skin Spot appears to develop best under cold, damp conditions. In 1952 temperatures were notably below average during January and February in the eastern counties (see this JOURNAL, 1952, **1**, 100–1). It may well have been that temperatures within the clamps were low at the time when *Oospora* was penetrating the tissues of the IPC-treated potatoes. Some other factor, such as maturity of the skins of the tubers at the time of the IPC application, may have contributed to the severity of the effects in 1952, but no evidence is available of any such additional factor common to all the cases that arose.

Thanks are due to the late Dr. W. A. R. Dillon Weston for his guidance in this work ; to Mr. H. W. Wheeler for the photographs ; and to other members of the Plant Pathology Department at Anstey Hall for their help.

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EFFECT OF POWDERY MILDEW ON THE YIELD OF SPRING-SOWN BARLEY

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Cereal Powdery Mildew, caused by *Erysiphe graminis* DC., occurs in Britain every year, but its incidence varies greatly from year to year and from crop to crop. By killing the leaves, the fungus must decrease the photosynthetic activity of the plants, and it can be expected to reduce yields when much of the leaf area is affected. There have been no measurements of losses caused by mildew in Britain, but in the U.S.A., by comparing the yields of resistant (Atlas 46) and susceptible (Atlas) varieties of wheat, Schaller (1951) concluded that mildew could decrease the yield by 25 per cent. This paper describes a field experiment carried out in 1954 with spring-sown barley in which mildew decreased the grain yields by as much as 22 per cent.

The trial layout, on Great Field at Rothamsted, comprised 3 randomized blocks, each of 4 plots of one-seventieth of an acre, on fertile land dressed with 2 cwt. sulphate of ammonia on May 27. Six plots were drilled at 2 bushels per acre on March 22, and 6 plots on April 5. On each occasion, three were drilled with a mildew-susceptible variety (Plumage Archer) and three with a mildew-resistant variety (Haisa II). Each plot was split into halves, one of which was not sprayed, and the other sprayed. The spraying was done with a knapsack machine on May 13 and 26, June 15 and 23, and July 8, at the rate of 160 gallons per acre, using lime sulphur at 1 in 80 (by volume) with 0·2 per cent of sulphonated lorol to act as a wetter. Five groups of three Plumage Archer barley plants carrying many pustules of *E. graminis* were planted in the unsprayed sub-plots of Plumage Archer on May 17.

Seedlings began to emerge on April 4 in the plots sown on March 22, and on April 20 in those sown on April 5. No mildew was seen until after the infected plants had been introduced, but it then spread rapidly through the unsprayed plots of Plumage Archer. The "Infection Index" method was used for the assessment of mildew (Last, 1953). Fig. 1 shows the mean number of sporing pustules per unit area (100 sq. cm.) of all the leaf blades on the main stems of the two varieties over the whole period from May to ripening. Until spraying was stopped in mid-July—because of the damage done to the crop when walking through it—the sprayed plots of Plumage Archer had only one-tenth the infection index of the unsprayed plots, but after this the two plots differed less. The later-sown crop was more heavily infected than the earlier sown ; it became resistant in August, when infection showed by the production of small necrotic spots instead of sporing pustules. Very little mildew appeared on Haisa II. Fig. 1 gives the infection index for the unsprayed late-sown plot only of Haisa II, which was the most infected. The infection indices for unsprayed plots on June 23 were 1·3 and 2·6 respectively for the early- and late-sown Haisa II, compared with 70 and 169 for the early- and late-sown Plumage Archer. On June 23, when these assessments were made, the early-sown Plumage Archer and Haisa II, in both the sprayed and unsprayed plots, were at growth stage 10 on the Feekes scale (as illustrated by Large, 1954), while the later-sown were at stage 9.

The incidence of mildew was measured only on the leaf blades. This was done because the leaf sheaths, except that of the flag leaf, probably contribute

little, if anything, to the photosynthesis of the plant (Boonstra, 1929). The leaf sheaths can become mildewed, but they are rarely affected seriously until the corresponding leaf blades are killed. The infection index records only the number of pustules and not the proportion of the total leaf area affected, for pustules differ considerably in size and in the extent to which uninvaded tissue becomes diseased. The cells beneath or above pustules become increasingly yellow as the pustules age.

In addition to measuring the infection index, the proportion of leaves affected by mildew was estimated by eye, totalling the area covered by pustules and that discoloured. The areas of the living leaves affected on June 22 were 23·0 per cent and 20·0 per cent of the unsprayed and 5·7 per cent and 1·8 per cent of the sprayed plants of Plumage Archer for the early- and late-sowings respectively. This figure of 20 per cent of the leaf area affected represents a severe mildew attack, as leaves die when 50–60 per cent of their area is affected.

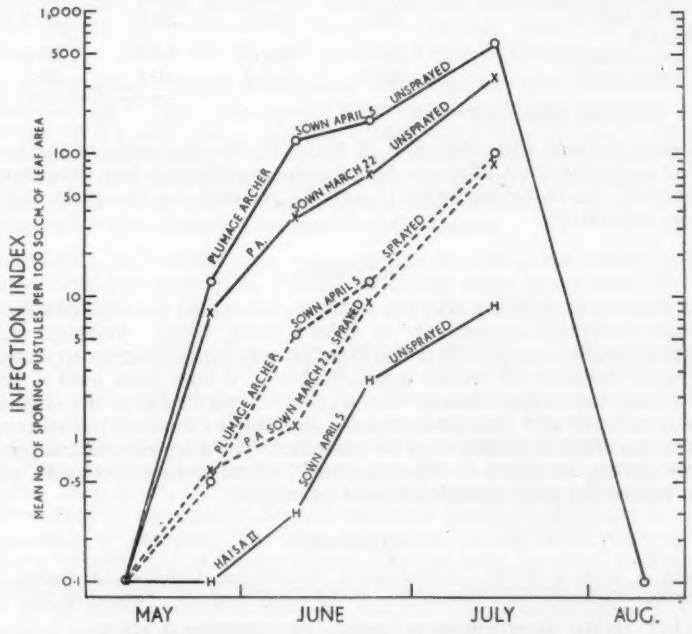

Fig. 1. Progress of mildew on the leaves of sprayed and unsprayed Plumage Archer (P.A.) and unsprayed Haisa II at Rothamsted, 1954.

As the spray treatments did not affect the total area of the main stem leaves of Haisa II and there were no other diseases on either variety, the differences between sprayed and unsprayed Plumage Archer are assumed to be due to mildew. Mildew did not affect the total area of the main stem leaves of Plumage Archer until mid-June, when the leaf areas of the early- and late-sown crops were decreased by 16 and 36 per cent respectively by the premature death of the heavily infected leaves (see table). These differences were maintained thereafter.

To assess completely a mildew attack, two criteria must be measured: the effect of mildew on total leaf area, and the percentage of the total leaf area affected. Although there were more pustules per unit area on the late-sown crop than on the early-sown, the same proportion of the leaf area was affected in both. However, mildew decreased the total leaf area of the late-sown crop more than that of the early-sown, and this difference is reflected in the grain yields (see table below).

EFFECT OF SPRAYING ON LEAF AREA ON JUNE 23, AND ON YIELD OF GRAIN AT HARVEST PLUMAGE ARCHER AND HAISA II, 1954

	Total Area of Living Leaf-blades per Main Stem on June 23 *sq. cm.*		Mean Yield of Grain *cwt. per acre*	
	Sprayed	Unsprayed	Sprayed	Unsprayed
Plumage Archer				
sown March 22	117·3	98·2	36·9	32·1
sown April 5	148·1	95·2	36·1	28·1
Haisa II				
sown March 22	101·7	104·3	39·5	40·8
sown April 5	107·0	116·3	41·1	39·7
Significant difference (P = 0·05)			1·9	

Spraying did not affect the yield of Haisa II, but the yields of the heavily infected and unsprayed Plumage Archer were significantly less than those of the sprayed, the reduction being 13 and 22 per cent for the early and late sowings respectively.

DISCUSSION

The practice of applying nitrogen fertilizer, advocated for high cereal yields in Britain, increases susceptibility to mildew (Last, 1953). Although mildew has been controlled successfully in this experiment by repeated spray applications, this control method will remain impracticable on a farm scale until it can be done without mechanical damage to the crop. Nevertheless, in the absence of resistant varieties with properties equally desirable to those of the susceptible varieties, the effect of mildew may be minimized by the simple cultural practice of early sowing, as shown in this experiment, where sowing two weeks earlier almost halved the yield reduction caused by mildew.

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EFFECT OF PREVIOUS CROPPING ON EYESPOT IN FOUR VARIETIES OF WINTER WHEAT

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In 1950, Eyespot, *Cercosporella herpotrichoides* Fron, was severe in the winter wheat variety trials and observation plots at the Norfolk Agricultural Station, Sprowston. More than 90 per cent of the straws were infected in pre-harvest samples from many plots. Considerable differences in straggling were noted between the varieties. Juliana, Alba, Atle and Vilmorin 27 showed considerable straggling ; Cappelle Desprez, King II and Scandia II were least affected ; while Eclipse, Holdfast, Pilot, Bersée and Nord Desprez were affected to an intermediate degree. It was noteworthy that Nord Desprez, potentially the highest yielding variety, gave 8 cwt. per acre less than Cappelle Desprez.

Previous workers (Glynne and Moore, 1949 ; Storey, 1947) had shown that the incidence of Eyespot was greatest where wheat or barley had been grown frequently on the same land, and that a break under non-susceptible crops or oats reduced the incidence. In view of these findings and of the great interest of possible varietal differences in susceptibility to Eyespot, a combined varietal and previous-cropping trial was conducted at Sprowston in 1950–53 as a part of the research and advisory programme of the station.

Four blocks, each of one acre, were sown on the site of the heavily infected wheat in 1950, and cropped as follows, the blocks being in the order IV, II, I, III, in the field :

	I	II	III	IV
1951	Spring barley	Spring barley	Sugar beet	S.100 white clover
1952	Spring barley	Fodder beet	Spring oats	S.100 white clover

All the crops received the normal cultural and manurial treatments of the farm. In the autumn of 1952 each block was divided into five plots, which were sown with four varieties of winter wheat—Cappelle Desprez, Hybrid 46 and Juliana, each at 2½ bushels per acre, and Bersée at 2½ and also 1½ bushels per acre. Bersée was included at two seeding rates following the observation by Glynne (1951) and Salt (1953) that the lower seeding rate tended to reduce the incidence of Eyespot. The plots were sown, in the same order in each block, on October 23. A sixteen-coulter drill was used, the third coulter from each end being blocked to give a 10-row harvest plot. The seedbed received 4 cwt. of an NPK compound fertilizer, and two top dressings each of 1½ cwt. per acre of sulphate of ammonia were given on March 7 and March 26 after a slight attack of wireworm and Wheat Bulb fly.

INCIDENCE OF EYESPOT IN 1953

The wheat plots were examined on March 9, 1953, and no Eyespot infection was then found ; on April 10 it was fairly easily found on all varieties in block I and on occasional tillers in block II, but not in the other blocks. The plots were sampled systematically on July 27, before harvest. Each was divided into two sub-plots 60 yards long, from both of which five samples were taken. Each sample consisted of the plants growing in 1-foot lengths of two adjacent rows, in positions taken at random. Outside rows were not sampled.

The straws were examined and a record made of those free from disease, and those infected by Eyespot, Sharp Eyespot, and Take-all. Eyespot-infected straws were classified into those with slight, and severe or deep lesions, the categories being those consistently used at Rothamsted by Glynne and Salt. The percentage of straws straggled and the area lodged in each plot was estimated by eye shortly before harvest. Sub-plots were cut by combine harvester on August 19 and 20 and the yields of grain determined, with correction to 14 per cent moisture content. The four outside buffer rows of each plot were discarded, so that the area of each plot harvested was $\frac{1}{48}$ acre. Laid plots were recovered with negligible loss.

MEAN PERCENTAGES OF STRAWS INFECTED AND SEVERELY INFECTED WITH EYESPOT; STRAWS PER FOOT OF DRILL; PERCENTAGE OF STRAWS STRAGGLED, AND AREA LODGED, AT HARVEST. SPROWSTON, JULY 27, 1953

Variety and Rate of Sowing		1951 : 1952 :	I Barley Barley	II Barley Beet	III Beet Oats	IV Clover Clover	Mean I–IV
Bersée	Straws straggled		20	15	10	10	
1½ bushels	Area lodged		5	5	0	0	
	Straws per foot		12·1	18·9	11·3	18·7	15·2
	Eyespot		82·7	77·5	60·2	8·3	57·1
	Severe Eyespot		**23·0**	**30·3**	**9·2**	**0·5**	**15·7**
	Yield (cwt. per acre)		28·5	39·5	40·1	49·1	39·5
Bersée	Straws straggled		20	20	10	15	
2½ bushels	Area lodged		10	5	0	0	
	Straws per foot		14·1	20·6	14·2	20·1	17·2
	Eyespot		87·5	81·0	44·2	23·8	59·1
	Severe Eyespot		**43·6**	**28·4**	**9·4**	**4·4**	**21·4**
	Yield (cwt. per acre)		27·8	37·1	40·9	48·2	38·5
Hybrid 46	Straws straggled		10	5	5	5	
2½ bushels	Area lodged		0	0	0	0	
	Straws per foot		12·9	17·4	12·9	18·1	15·3
	Eyespot		80·6	81·3	52·3	18·7	58·2
	Severe Eyespot		**29·0**	**40·2**	**11·2**	**4·2**	**21·1**
	Yield (cwt. per acre)		29·4	39·6	40·7	51·8	40·4
Cappelle	Straws straggled		5	5	5	5	
2½ bushels	Area lodged		0	0	0	0	
	Straws per foot		10·4	20·5	14·9	19·2	16·2
	Eyespot		83·6	73·9	22·7	15·0	48·8
	Severe Eyespot		**16·8**	**10·7**	**1·3**	**1·3**	**7·5**
	Yield (cwt. per acre)		34·0	45·2	41·4	50·0	42·6
Juliana	Straws straggled		5	5	20	20	
2½ bushels	Area lodged		95	90	5	70	
	Straws per foot		16·9	18·2	18·6	24·3	19·5
	Eyespot		85·5	82·4	32·7	13·3	53·3
	Severe Eyespot		**74·9**	**63·2**	**4·1**	**5·9**	**37·0**
	Yield (cwt. per acre)		18·3	23·8	38·5	31·3	28·0
	Mean Eyespot infection		83·9	79·2	42·4	15·8	
	Mean Severe Eyespot		**37·4**	**23·5**	**7·0**	**3·2**	
	Mean Yield (cwt. per acre)		27·6	37·1	40·3	46·1	

Sharp Eyespot, *Corticium solani* (Prill. and Delacr.) Bourd. and Galz., was present over the whole area. There was no apparent difference in the incidence of this disease according to variety, and little difference between blocks I–IV, which had respectively 12·3, 15·3, 12·4 and 9·1 per cent of the straws infected. The lesions were mostly superficial and did not appear to have caused any appreciable damage. Only five straws infected with Take-all, *Ophiobolus graminis* (Sacc.) Sacc., were found among all the samples. Eyespot and not Take-all was the important disease, and here it is of interest to note that the

soil was a light loam over brickearth, and the cropping before 1950 included seven wheat or barley crops in eleven years. The whole of the trial data relevant to Eyespot is assembled in the table.

No lodging occurred in the short-strawed varieties, Hybrid 46 and Cappelle Desprez, and in these varieties straggling was slight. The extensive lodging of Juliana following the clover cropping was probably due to the heavy straw produced, as Eyespot was low. Mildew, *Erysiphe graminis* DC, was very severe in this plot. In the Juliana in blocks I and II (after barley-barley and after barley-roots) Eyespot incidence was high and probably the chief factor causing lodging. Straggling appeared to be slightly reduced in two of the four plots of Bersée drilled at the lower seed rate. The mean height of the straw in all samples, measured to the base of the ear, showed no effect of previous cropping or seed rate ; for Bersée it was 42·3 inches, for Hybrid 46 37·6 inches, for Cappelle Desprez 37·9 inches, and for Juliana 49·0 inches. Juliana has a thin-walled straw ; Cappelle Desprez, Hybrid 46 and Bersée are normally all thick-walled.

After the two barley crops (block I) more than 80 per cent of the straws were infected with Eyespot in all varieties. The one-year break under roots in 1952 (block II) had little, if any, effect in reducing the incidence of Eyespot. A two-year break of roots followed by oats (block III) reduced the mean percentage of straws infected to about 40 per cent. The most effective break was the two years under clover (block IV), which reduced the incidence of Eyespot to about 16 per cent.

Bersée, the only variety sown at two seed rates, had appreciably fewer plants with severe Eyespot infection at the lower seed rate on two of the four blocks. Although about 40 per cent more seed was used at the higher seed rate, only 12 per cent more stems were present at harvest, and the yield was, in fact, slightly less than at the lower seed rate.

There was little varietal variation in the mean percentage of straws showing *any* degree of infection with Eyespot within each block, but there were great differences in the percentages of straws *severely* infected. With the same seed rate, Cappelle Desprez had only about one-third as much severe infection as any other variety. Juliana was the most severely affected variety, while Bersée and Hybrid 46 were intermediate and about equally infected. These differences in amounts of severe infection between varieties were not due to differences in densities of the plots, for although on the average Juliana had most straws per plot, the populations of the Cappelle Desprez plots were not greatly different from those of the other two varieties.

It would appear that there are true differences in varietal resistance, not to initial infection by Eyespot, but to penetration or development of the Eyespot lesions. In this respect, Cappelle Desprez was found to be the most resistant variety in the present trials. In field experiments in France, Vincent *et al.* (1952) found Cappelle Desprez and Bersée to be less infected than other varieties, with Cappelle Desprez very much less infected than its sister variety, Nord Desprez.

In all varieties (see table), yields tended to increase as the percentage of straws infected by Eyespot decreased. The highest yields were obtained after the two years under clover ; intermediate yields followed roots and oats, and barley and oats, and the lowest yields were those after the two barley crops. These yield differences were, of course, also a reflection of the fertility level of the soil resulting from the treatment of the previous crops. The roots in block II, for example, received heavier dressings of fertilizer than the barley crops in block I, and the wheat yields were therefore understandably lower in block I, Eyespot

The straws were examined and a record made of those free from disease, and those infected by Eyespot, Sharp Eyespot, and Take-all. Eyespot-infected straws were classified into those with slight, and severe or deep lesions, the categories being those consistently used at Rothamsted by Glynne and Salt. The percentage of straws straggled and the area lodged in each plot was estimated by eye shortly before harvest. Sub-plots were cut by combine harvester on August 19 and 20 and the yields of grain determined, with correction to 14 per cent moisture content. The four outside buffer rows of each plot were discarded, so that the area of each plot harvested was $\frac{1}{48}$ acre. Laid plots were recovered with negligible loss.

MEAN PERCENTAGES OF STRAWS INFECTED AND SEVERELY INFECTED WITH EYESPOT; STRAWS PER FOOT OF DRILL; PERCENTAGE OF STRAWS STRAGGLED, AND AREA LODGED, AT HARVEST. SPROWSTON, JULY 27, 1953

Variety and Rate of Sowing		1951 : 1952 :	I Barley Barley	II Barley Beet	III Beet Oats	IV Clover Clover	Mean I–IV
Bersée	Straws straggled	.. ..	20	15	10	10	
1½ bushels	Area lodged	.. .. ..	5	5	0	0	
	Straws per foot	.. .. ..	12·1	18·9	11·3	18·7	15·2
	Eyespot	.. .. ..	82·7	77·5	60·2	8·3	57·1
	Severe Eyespot	.. .. ..	**23·0**	**30·3**	**9·2**	**0·5**	**15·7**
	Yield (cwt. per acre)	.. ..	28·5	39·5	40·1	49·1	39·5
Bersée	Straws straggled	.. ..	20	20	10	15	
2½ bushels	Area lodged	.. .. ..	10	5	0	0	
	Straws per foot	.. .. ..	14·1	20·6	14·2	20·1	17·2
	Eyespot	.. .. ..	87·5	81·0	44·2	23·8	59·1
	Severe Eyespot	.. .. ..	**43·6**	**28·4**	**9·4**	**4·4**	**21·4**
	Yield (cwt. per acre)	.. ..	27·8	37·1	40·9	48·2	38·5
Hybrid 46	Straws straggled	.. ..	10	5	5	5	
2½ bushels	Area lodged	.. .. ..	0	0	0	0	
	Straws per foot	.. .. ..	12·9	17·4	12·9	18·1	15·3
	Eyespot	.. .. ..	80·6	81·3	52·3	18·7	58·2
	Severe Eyespot	.. .. ..	**29·0**	**40·2**	**11·2**	**4·2**	**21·1**
	Yield (cwt. per acre)	.. ..	29·4	39·6	40·7	51·8	40·4
Cappelle	Straws straggled	.. ..	5	5	5	5	
2½ bushels	Area lodged	.. .. ..	0	0	0	0	
	Straws per foot	.. .. ..	10·4	20·5	14·9	19·2	16·2
	Eyespot	.. .. ..	83·6	73·9	22·7	15·0	48·8
	Severe Eyespot	.. .. ..	**16·8**	**10·7**	**1·3**	**1·3**	**7·5**
	Yield (cwt. per acre)	.. ..	34·0	45·2	41·4	50·0	42·6
Juliana	Straws straggled	.. ..	5	5	20	20	
2½ bushels	Area lodged	.. .. ..	95	90	5	70	
	Straws per foot	.. .. ..	16·9	18·2	18·6	24·3	19·5
	Eyespot	.. .. ..	85·5	82·4	32·7	13·3	53·3
	Severe Eyespot	.. .. ..	**74·9**	**63·2**	**4·1**	**5·9**	**37·0**
	Yield (cwt. per acre)	.. ..	18·3	23·8	38·5	31·3	28·0
	Mean Eyespot infection	..	83·9	79·2	42·4	15·8	
	Mean Severe Eyespot	.. ..	**37·4**	**23·5**	**7·0**	**3·2**	
	Mean Yield (cwt. per acre)	..	27·6	37·1	40·3	46·1	

Sharp Eyespot, *Corticium solani* (Prill. and Delacr.) Bourd. and Galz., was present over the whole area. There was no apparent difference in the incidence of this disease according to variety, and little difference between blocks I–IV, which had respectively 12·3, 15·3, 12·4 and 9·1 per cent of the straws infected. The lesions were mostly superficial and did not appear to have caused any appreciable damage. Only five straws infected with Take-all, *Ophiobolus graminis* (Sacc.) Sacc., were found among all the samples. Eyespot and not Take-all was the important disease, and here it is of interest to note that the

soil was a light loam over brickearth, and the cropping before 1950 included seven wheat or barley crops in eleven years. The whole of the trial data relevant to Eyespot is assembled in the table.

No lodging occurred in the short-strawed varieties, Hybrid 46 and Cappelle Desprez, and in these varieties straggling was slight. The extensive lodging of Juliana following the clover cropping was probably due to the heavy straw produced, as Eyespot was low. Mildew, *Erysiphe graminis* DC, was very severe in this plot. In the Juliana in blocks I and II (after barley-barley and after barley-roots) Eyespot incidence was high and probably the chief factor causing lodging. Straggling appeared to be slightly reduced in two of the four plots of Bersée drilled at the lower seed rate. The mean height of the straw in all samples, measured to the base of the ear, showed no effect of previous cropping or seed rate ; for Bersée it was 42·3 inches, for Hybrid 46 37·6 inches, for Cappelle Desprez 37·9 inches, and for Juliana 49·0 inches. Juliana has a thin-walled straw ; Cappelle Desprez, Hybrid 46 and Bersée are normally all thick-walled.

After the two barley crops (block I) more than 80 per cent of the straws were infected with Eyespot in all varieties. The one-year break under roots in 1952 (block II) had little, if any, effect in reducing the incidence of Eyespot. A two-year break of roots followed by oats (block III) reduced the mean percentage of straws infected to about 40 per cent. The most effective break was the two years under clover (block IV), which reduced the incidence of Eyespot to about 16 per cent.

Bersée, the only variety sown at two seed rates, had appreciably fewer plants with severe Eyespot infection at the lower seed rate on two of the four blocks. Although about 40 per cent more seed was used at the higher seed rate, only 12 per cent more stems were present at harvest, and the yield was, in fact, slightly less than at the lower seed rate.

There was little varietal variation in the mean percentage of straws showing *any* degree of infection with Eyespot within each block, but there were great differences in the percentages of straws *severely* infected. With the same seed rate, Cappelle Desprez had only about one-third as much severe infection as any other variety. Juliana was the most severely affected variety, while Bersée and Hybrid 46 were intermediate and about equally infected. These differences in amounts of severe infection between varieties were not due to differences in densities of the plots, for although on the average Juliana had most straws per plot, the populations of the Cappelle Desprez plots were not greatly different from those of the other two varieties.

It would appear that there are true differences in varietal resistance, not to initial infection by Eyespot, but to penetration or development of the Eyespot lesions. In this respect, Cappelle Desprez was found to be the most resistant variety in the present trials. In field experiments in France, Vincent *et al.* (1952) found Cappelle Desprez and Bersée to be less infected than other varieties, with Cappelle Desprez very much less infected than its sister variety, Nord Desprez.

In all varieties (see table), yields tended to increase as the percentage of straws infected by Eyespot decreased. The highest yields were obtained after the two years under clover ; intermediate yields followed roots and oats, and barley and oats, and the lowest yields were those after the two barley crops. These yield differences were, of course, also a reflection of the fertility level of the soil resulting from the treatment of the previous crops. The roots in block II, for example, received heavier dressings of fertilizer than the barley crops in block I, and the wheat yields were therefore understandably lower in block I, Eyespot

infection being similar in both blocks. Juliana gave its highest yield in block III, where it remained standing. In block IV, where it lodged rather badly under the high nitrogen conditions, its yield was considerably reduced.

In blocks I and II, where Eyespot was worst, Cappelle Desprez yielded at least 5 cwt. more grain per acre than any of the other varieties.

We wish to express our thanks to the Director and Executive Committee of the Norfolk Agricultural Station for facilities for carrying out this work on their trials ; to Dr. Mary D. Glynne for much helpful advice ; to Mr. G. A. Salt for checking the slight and severe Eyespot separation ; and to Mrs. R. Jeater for assistance in the sampling and examination of samples.

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A ROLLING METHOD FOR OPENING CYSTS OF POTATO ROOT EELWORM

by ELIZABETH REID

Nematology Department, Rothamsted Experimental Station

The two methods described by D. W. Fenwick (*J. Helminth.*, 1952, **26**, 55–68) for the opening of cysts of the Potato Root Eelworm, *Heterodera rostochiensis* Woll., are to squash the soaked cysts in a watch glass with a small, circular glass spatula, or to crush them between microscope slides. The slide method has been found to give the higher counts, but both methods are inferior to dissection under the microscope, owing to mechanical damage and to trapping of the cyst contents within unbroken pieces of the cyst wall. The use of a 1 per cent solution of bleaching powder recommended with these methods has disadvantages in that it has a solvent action on the damaged cyst contents. A Hagedorn-needle method for the dissection of cysts (Reid, E. in appendix (1952) *loc. cit.*) has proved reliable, and it has enabled the dissection of a hundred cysts to be accomplished in one minute after some practice, but the speed at which it can be used on a run of samples is strictly limited by the element of fatigue.

In an attempt to overcome this disadvantage and to improve the efficiency of extraction, a special slide has now been adopted on which the soaked cysts can be disrupted by rolling. The first experimental slide was made by cementing two thin strips of celluloid, ½ inch wide, on to a strip of perspex 5 inches long by 2½ inches wide, in such a way as to leave a channel on the slide about 1½ inches wide and 0·12 mm. deep. Cysts were spread in this channel with a little water, and rolled several times with a piece of 7 mm. glass rod. The clearance between the roller and the bottom of the channel obviated the danger of crushing the eggs and larvae. It was found that most of the cyst contents were freed, but some masses of eggs were still trapped in portions of the cyst wall. The material was therefore washed off the slide into a boiling tube (of 100 ml. capacity) and the suspension agitated with an electric stirrer for about half a minute. This was found to be sufficient to break up the egg masses and empty the cyst shells.

Experience with this method has shown that any damage sustained by the cyst contents is slight, and that three rollings—forwards, backwards, and forwards again—are sufficient to open most of the cysts. More rolling merely increases the proportion of released larvae, owing to pressure on the eggs. There should not be more than a thin, even film of water over the surface of the channel. If too much water is present, the eggs and larvae are drawn along the roller by capillarity and crushed on the " pavements ". Bleaching powder has not been found to be necessary with this method. The mechanical stirring is more efficient if given in three successive bursts of ten seconds, rather than in one continuous period of half a minute. When making estimates of cyst contents, batches of cysts are " rolled ", made up to a known volume in the boiling tube, agitated, and aliquot samples are taken for counting eggs and larvae.

The perspex slide can be replaced for permanent use by a metal slide, the central channel being milled out accurately to 0·005 inches, or 0·127 mm., below the borders. Slides 5½ inches long by 2½ inches wide can be used for batches of up to 2,000 cysts. For smaller batches of up to 200 cysts, a slide measuring 3 inches by 1 inch with borders ¼ inch wide has been found suitable. The electric stirrer used has been a modified domestic machine of the type used for malted milk. A standard laboratory homogenizer is equally suitable if fitted with a single 8-inch spindle with one terminal stirring button having an undulated edge.

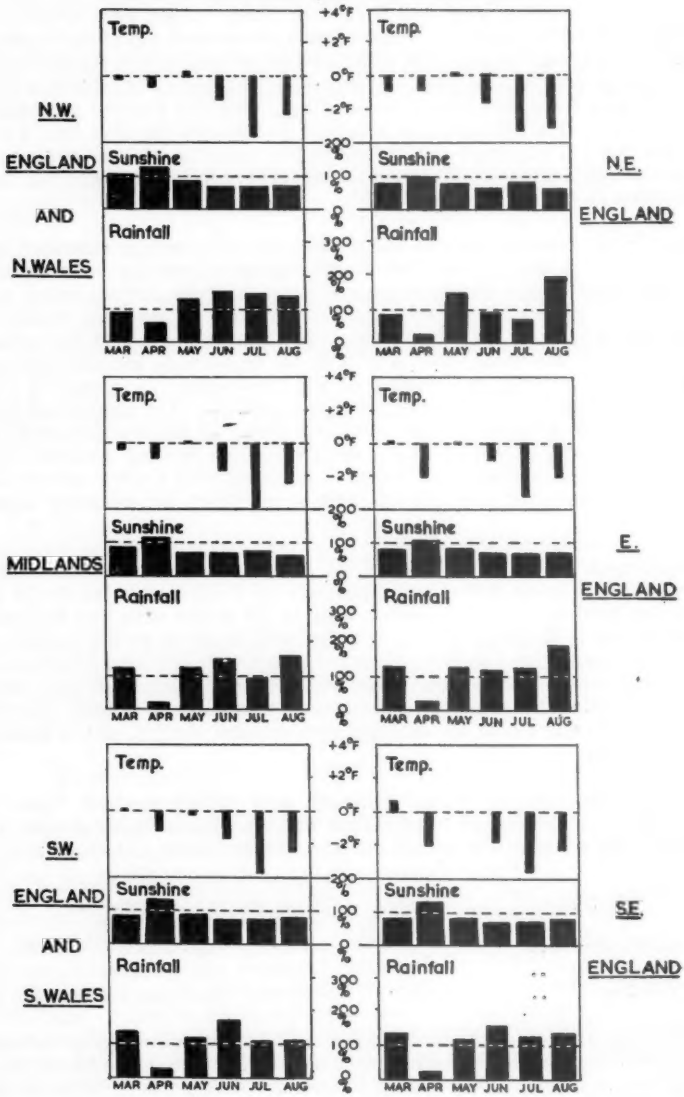
The efficiency of the Hagedorn-needle and rolling methods have been compared on a number of hand-picked batches of one hundred cysts from differing types of soil. The results of three such tests were as follows :

Sample from :	Number of Eggs and Larvae Extracted per Cyst		
	Rolling	Hagedorn-needle	Difference
Rothamsted	169·6	142·1	Significant at P = 0·02
Bedfordshire	83·7	69·6	Not significant
Duddington	202·7	165·2	Significant at P = 0·05

Higher egg and larval counts have been obtained consistently by the rolling method, although, as in the examples above, the increase in the count has not always been significant. The rolling method is not appreciably faster than the Hagedorn-needle method, but it is far less tedious and does not require such a high degree of manipulative skill.

MARCH-AUGUST WEATHER 1954

Variations from average



THE WEATHER OF ENGLAND AND WALES*

SPRING AND SUMMER, 1954

The most striking feature of the weather of the six months under review has been the cool, rainy and relatively sunless months of June, July and August in all districts of England and Wales. The most recent summer of comparable coldness to that of 1954 occurred in 1920, and for a similar combination of low temperature, low sunshine and high rainfall, it is necessary to go back to 1903.

March began with cold weather and widespread snow, and many air temperatures of 20° F. or less were recorded. The snow soon disappeared, except on high ground, and southerly winds on the 10th brought a rapid rise of temperature. A return to colder conditions quickly set in on the 13th, but an unsettled westerly type of wind replaced it about a week later, and this lasted for the rest of the month. Low rainfall was a feature of the April weather, and there was an absolute drought in many parts of England and Wales. Nights were cold with frequent air and ground frosts, and although sunshine was slightly above average, the general level of mean daily temperature was appreciably below the seasonal normal. Although parts of south-west England were without rain from the 6th to the 13th, the total rainfall for May was generally above average ; much of the rain fell in thunderstorms which occurred mainly at the beginning of the month. For the month as a whole mean temperatures were about average ; snow, however, fell on the 2nd as far south as the Chilterns, whilst in the second and last weeks, mid-afternoon temperatures in the eighties were recorded in south-east England.

Rainfall in June was well above, and temperature appreciably below, the average for the month. On the 5th, widespread thunderstorms with very heavy rain broke out in the Midlands and the south-east, and rainy weather continued for some seven days—from the 6th to the 12th. Then followed a period of relatively dry weather, especially in the eastern half of England, but the month closed with a return to cloudy, cool weather and northerly winds with rain or showers. July was a cool month, and in the south and west a wet one also. Daytime maxima were frequently 10° F. below the corresponding seasonal average of about 70° F. Night minima did not deviate so markedly from average, although on the 5th and 6th ground temperatures fell below freezing point in many parts of Hampshire. The middle of the month was rather changeable, with a few fine warm days, especially in the south and east, where thunderstorms occurred. It was, on the whole, cloudy and cool ; hill and coast fog spread along the south and west coasts and gales were reported from those areas on the 11th and 13th. Towards the end of the month cloudy, cooler weather was experienced, with considerable rainfall and winds reaching gale force in many parts of the south and west on the 27th and 28th. Early in August, afternoon temperatures exceeded 70° F. for a few days, but thereafter fell to rather below the seasonal average, although for a few days towards the end of the month there was some fine weather with a considerable amount of sunshine, bringing temperatures in the south-east up in the eighties. Frequent thunderstorms occurred during August with heavy rain and, at times, hail.

The weather in each of the six months from March to August (inclusive) is represented graphically on page 30. Figures for the six districts of England and Wales are shown in terms of the deviation from the average of air temperature, sunshine and rainfall.

* These notes, and the diagram on page 30, are provided by the Agricultural Branch of the Meteorological Office and published by permission of the Director.

NEW OR UNCOMMON PLANT DISEASES AND PESTS IN ENGLAND AND WALES

Frit Fly Damage on Wheat. At the beginning of July 1954, damaged ears of spring wheat (Atle) were received from Lawshall, West Suffolk. The damage was confined to the tips, extending from ½ inch to 1½ inches down the ear. The affected spikelets were under-developed, with the grain entirely missing, atrophied, or occasionally partly destroyed. Some of the glumes and pales appeared intact, while others were either partly torn or tunnelled through to the centre of the spikelet. There were also signs of feeding on the rachis, usually near the point of attachment of the spikelet. A very clear line of division could be seen between the affected and the healthy portions of each ear, the damaged part appearing rather like a whip tail on top of the broader, normally developed lower portion (Plate II, 1). A single larva and several pupae (Plate II, 2) were found on the damaged ears. The adult flies which later emerged were identified as *Oscinella frit* L., the identification being confirmed by Mr. J. E. Collin. Over the whole field, which was sown down in the first week in April, there were one or two affected ears per square yard.

Damage to ears of wheat by Frit fly is familiar on the Continent of Europe (Balachowsky, A. and Mesnil, L., *Les Insectes Nuisibles aux Plantes Cultivees*, 1935). In this country, apart from a single specimen of *Oscinella* sp. bred from a wheat kernel (Curtis, J., *Farm Insects*, 1860), it does not appear to have been previously recorded or described. However, Mr. B. D. Moreton has informed me that he also found damage to Atle wheat by Frit fly early in July 1954, at Aylesford, Kent. There, about 25 per cent of the heads had bleached tips, about a quarter of which subsequently proved to have been damaged by Frit fly.

Thanks are due to Mr. W. E. Dant for the photographs.

T. J. LEGOWSKI

Ergot on Canary Grass. Ergot, *Claviceps purpurea* (Fr.), was found in a 14-acre field of canary grass, *Phalaris canariensis*, at Great Chesterford, Essex, in the autumn of 1954 (Plate III, 1). The crop was stooked when examined but estimates of ergots in the stooks indicated that about 1–2 per cent of the heads in the standing crop were affected. Infection seemed to have been evenly distributed throughout the field. The weed grass, *Alopecuris myrosurioides*, was also affected in this field. The 1953 crop was wheat and the rotation was one in which wheat and barley figures prominently. Although canary grass was grown elsewhere on the farm, it had not previously been on this particular field. This is the first record of ergot on canary grass in Britain.

JUNE V. IVES

Eelworm in Scabious. A plant of *Scabiosa caucasica* "Clive Greaves" infested with *Aphelenchoides fragariae* (Bos) was received from West Row, Suffolk, in July 1950. The eelworms were living endoparasitically in the leaves, which were dying off. The damage within the plantation was generally slight, although odd plants were heavily infested. Damage by this eelworm to scabious was subsequently reported in 1952 from Hampshire, Lancashire, Westmorland, Cumberland and Northumberland. Also in 1952, a scabious plant infested with three species of *Aphelenchoides* was received from another locality in Suffolk. The species present were *A. fragariae*, *A. ritzema-bosi* and *A. blastophthorus*. This is a first record of attack on *Scabiosa caucasica* by *A. fragariae*.

E. B. BROWN

Halo Blight of Oats. In mid-June 1954 a widespread attack of Halo Blight, *Pseudomonas coronafaciens* (Elliott) Stapp, occurred throughout an extensive collection of spring oat breeding material at the Welsh Plant Breeding Station near Aberystwyth, Cardiganshire. Within a few days the disease had also been seen on a few trial plots at Cambridge and was present and sometimes severe—particularly on plants at the edges of plots—on a trial of eighteen spring varieties at Cockle Park, Northumberland. Later, slight infection was reported in four fields in Northumberland, and a few affected plants were found in a trial in Cumberland. Halo Blight has not previously been recorded in England and Wales; it was first seen in Scotland in 1947 (Noble, M., *Scot. Agric.*, 1949–50, **29**, 162–5) and since then has been found there regularly.

D. L. G. DAVIES, MARY NOBLE AND THERESA NORMAN

Flower Scorch of Chrysanthemum. In early December 1953, chrysanthemums growing in unheated Dutch lights at Tolpuddle, Dorset, were found to be showing an unusual flower scorch, of a kind that had been noticed by Mr. L. Ogilvie in October 1936 at Walton-in-Gordano, Somerset, and which he had then examined with Dr. C. J. Hickman. Further specimens were received later in 1953 from nurseries at Salisbury and at Frome, Somerset. The first symptoms appear either as small rusty-brown spots or as larger, rather oval, translucent lesions in the outer florets. Affected florets wither and turn brown rapidly (Plate III, 2). The whole flower ultimately becomes brown and withered. *Botrytis* often masks the original infections very quickly, but when these are examined before secondary invasion many of them are found to be covered with a mycelial felt, consisting chiefly of a close palisade of sporidiophores, bearing half-moon shaped binucleate sporidia. These measure 10–18 by 7–13 μ and are usually asymmetrically attached to the sporidiophores. On germination, they produce a stout mycelium with clamp connections. On the host, appressoria are soon formed and an intracellular mycelium develops. On cornmeal and potato dextrose agar single-spore cultures produced flat, slow-growing cultures with very scanty aerial hyphae. The fungus resembles *Entyloma calendulae* (Oudem.) de Bary in some respects but a detailed study of its identity has not yet been completed.

Preliminary inoculations have reproduced the symptoms on chrysanthemums (variety: Sweetheart) under conditions of high humidity and a temperature of 55–60° F. Similar symptoms have also been produced on *Bellis perennis* (var. Dresden China), but not, so far, on leaves or petals of *Calendula*. In the South-Western Province (Bristol) we have now seen the disease on over seventy chrysanthemum varieties. Mr. S. C. Melville and Mr. P. Wiggell, of Starcross, have informed me (*in lit.*) that they found the same disease on a nursery at Bishopsteignton, Devon, in October 1954, and that it was there present on the majority of some thirty midseason varieties.* In their inoculation experiments they have successfully infected blooms of dahlia, varieties Yellow Pet and Edith.

A. G. ROBERTSON

* During 1954 this disease was found on at least six more nurseries in the South-West and was also recorded from Sussex and Herts.

DIPTEROUS PESTS OF CEREALS IN 1954

Leatherjackets, *Tipula* spp., were, in general, less numerous than in 1953, but high populations occurred in parts of Hampshire, Berkshire and Oxfordshire, on crops after late-ploughed leys or following old pastures. Only in a few instances did serious damage result, and these were mainly in the north and in the West Midlands.

Damage by Frit fly, *Oscinella frit* (L.), was much above normal in the south-east ; in some areas of West Sussex a 90 per cent crop loss was experienced. Most of the attacks were after late-ploughed leys or weedy stubbles, but there was some damage after clean stubbles. Many cases of damage, mainly light, occurred in the eastern counties, mostly on wheat, although oats, rye, and ryegrass-rye mixtures were also infested. In the south-west, the weather was such that crops, which normally would have grown sufficiently to be free or suffer only slight attack, sustained moderate–heavy attacks. Very little damage occurred in the northern counties ; in Yorkshire, Lancashire and the West Midlands attacks were also less severe than in 1953. Elsewhere in the country damage was about normal.

Damage due to Wheat Bulb fly, *Leptohylemyia coarctata* (Fall.), was on a considerably reduced scale, as compared with 1953. However, widespread attacks, a few of which were severe, occurred in Yorkshire, the East Midlands—particularly in Lincolnshire—and the eastern counties. In North Gloucestershire 70 acres of wheat failed completely, and in another instance of severe damage the crop was adjacent to a field which suffered badly in 1953. The reduction in severity of damage in 1954 was probably due to the good growing conditions during the mild autumn, for by the time eggs were hatching —about 3 weeks later than usual owing to the cold spell—the plants were vigorous and, in most instances, well able to withstand attacks.

Bibionid larvae, probably *Dilophus febrilis* (L.), were found in very large numbers, mainly in poor cereal crops in several eastern counties. Invariably the previous crop was permanent grass or a ley, and often the growth was rank when ploughed in. Mycetophilids and leatherjackets were also present in some of the fields, and the leatherjacket population was such that there was little doubt that they were the main cause of the damage. In other fields where the crop was unsatisfactory, and where there was slight insect damage, bibionids were found in large numbers and few or no leatherjackets were present. Although often abundant, the mycetophilids were not thought to be affecting the crops. St. Mark's fly, *Bibio marci* (L.), larvae were numerous in a field of wheat in Dorset and were associated with ragged holes just above the bases of the plants.

Grass and Cereal flies—larvae of *Opomyza* spp.—were responsible for appreciable thinning of one wheat field, after late-ploughed ley, in Northumberland, and were present in another wheat crop in Durham. They also caused considerable damage to a wheat crop in Yorkshire, where the species was probably *O. germinationis* (L.). Up to one in ten tillers were attacked in a wheat crop in a Take-all trial in Dorset, by *Opomyza florum* (F.).

Larvae, mainly *Meromyza* sp., were present and associated with 50 per cent loss of wheat in a field in Hampshire, and with 95 per cent loss in Buckinghamshire.

Plant Pest Survey

(2064) Wt. 44 K.9 3/55 Hw.